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BIOASSESSMENT OF BIG MUDDY CREEK

ROOSEVELT AND SHERIDAN COUNTIES, MONTANA:

AQUATIC INVERTEBRATES AND HABITAT

JUNE, 2000

Report prepared for

Sheridan County Conservation District
Plentywood, Montana

By

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October, 2000

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INTRODUCTION

Benthic assemblages are aptly applied to aquatic bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations. Multimetric approaches to bioassessment use attributes of the assemblage in an integrated way to measure biotic integrity, defined by Karr and Dudley as "…the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitats within a region." The additive multimetric approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "… an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of aquatic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1995). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998). The first element is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied must be done, to assist in the interpretation of metric outcomes.

Relevant habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by quantities of organic materials, nutrients, metals, or other toxicants might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment. Habitat assessment data is even more important in the plains ecoregions, where the relationships between habitat variables and benthic community characteristics remain largely unknown.

This report summarizes data collected on June 6 – 8, 2000, from Big Muddy Creek, Roosevelt and Sheridan Counties, Montana by means of a multimetric method, an adaptation of the U.S. EPA's Rapid Bioassessment Protocols (RBP III) (Plafkin et al. 1989). Invertebrates were collected at three sites on Big Muddy Creek which is a tributary of the Missouri River located in the Northwestern Glaciated Plains ecoregion (Omernik et al.1997).

Selection of bioassessment metrics, assessment of habitat, and evaluation of benthic community attributes for this study were not straightforward tasks. The standard operating procedures manual for aquatic invertebrate sampling and analysis of the Montana Department of Environmental Quality (MT DEQ) (Bukantis 1998) recommends the use of ten metrics for assessing biota of streams in the Montana plains ecoregions, and a habitat assessment incorporating ten habitat measures thought to be related to disturbance and biology in streams with glide and pool prevalence. Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between disturbance, habitat measures, and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of independent measures of human-caused disturbance, habitat assessment elements, and biotic metrics and a test of the presumed relationship between them. Assurance of the validity of association between disturbance, habitat measures, and biotic metrics is particularly compelling in the Montana plains ecoregions through which Big Muddy Creek flows, since impairment of the biotic health of streams in this region is generally the result of non-point sources related to human-caused disturbances. Agricultural activities, cattle grazing, and flow alteration are predominant causes of stream degradation. The benthic assemblages of the plains ecoregions and the performance of the recommended bioassessment metrics have not yet been examined thoroughly enough to determine whether or not the individual metrics or their integrated scores can discriminate impaired conditions from good biotic health. This author (Bollman 1998) evaluated bioassessment metrics for the Montana valleys and foothill prairies ecoregion, and found that many metrics recommended for use in that region were not accurate in discriminating impaired from unimpaired conditions.

In addition, relationships between human-caused disturbance and the measures comprising the habitat assessment index used in this study are not understood, and have not yet been investigated in the Montana plains ecoregions. Recently, Fore and Bollman (2000) have studied the relationships between independent measures of disturbance, habitat features, and biotic metrics for three ecoregions of Idaho. This study found that many habitat assessment measures are either not strongly related to human-caused disturbance or they do not appear to have an appreciable effect on biotic metrics. Since neither the habitat measures nor the bioassessment metrics used at this time in the Montana plains ecoregions have been subjected to testing procedures, it is impossible to say with certainty that the habitat measures used here are associated with anthropogenic disturbance, and further, whether those habitat measures are associated with features of the biological communities of Big Muddy Creek represented by the bioassessment metrics. Therefore, the interpretations, scores, and conclusions presented in this report must be considered tentative, and the data should be reconsidered in the future, after research has been done to better elucidate these relationships.

METHODS

Aquatic invertebrates were sampled from twelve sites on Big Muddy Creek on June 6 – 8, 2000. Sampling site locations, identifiers, and descriptions are given in Table 1. Four sites from each of three reaches of Big Muddy Creek were sampled.

In addition to invertebrate sample collection, habitat quality was visually evaluated at each site and reported by means of the habitat assessment protocols recommended by Bukantis (1998) for streams with prevalent glides and pools. Certain other data relating to habitat and water quality were also collected, including water temperature, dissolved oxygen, pH, and conductance. Invertebrate samples and the associated habitat data were delivered to Rhithron Biological Associates, Missoula, Montana, for laboratory and data analyses.

In the laboratory, the RBP III sorting method was used to obtain subsamples of 300 (+/- 10%) organisms from each sample when possible. When samples contained fewer than 300 total organisms, all invertebrates present were used. Community structure, function, and sensitivity to impact were characterized for each subsample using a battery of ten attributes, or metrics, recommended by Bukantis (1998) for streams of the Montana plains ecoregions.

Table 1. Sampling site identifiers, descriptions and locations. Big Muddy Creek, June 6 – 8, 2000.

Sample ID	Description	Legal description	Latitude / Longitude
LBM – 2	Big Muddy Creek: Robert Olson	T28N R55 S17 SE¼	
LBM – 5	Big Muddy Creek: Farley Crossing	T28 R54 S1	
LBM – 9	Manning Lake Creek	T54 R29 S19 NE¼	
LBM – 11	Big Muddy Creek: Jim Anderson range unit	T29N R54E S4 SE¼	
MBM – 4	Big Muddy Creek: above Homestead control dam	T31N R55E S28 SE¼ SE¼ NE¼	48° 24' 7" / 104° 33' 14"
MBM – 10	Lower Wolf Creek	T32N R55E S33 NW¼ NE¼ SE¼	48° 29' 01" / 104° 33' 59"
MBM – 15	Big Muddy Creek: below Otter Creek	T33N R55E S25 SE¼ NW¼ NW¼	48° 25' 32" / 104° 28' 01"
MBM – 18	Big Muddy Creek: below Rom Hedges bridge	T34N R55E S27 NW¼ NW¼ SW¼	48° 40' 16" / 104° 30' 46"
UBM – 1	Big Muddy Creek: below Plentywood lagoons	T35N R55E S30 NE¼	48° 45' 42.17" / 104° 34' 01.23"
UBM – 2	Big Muddy Creek: upstream ~ 1 mile from Plentywood		48° 06' 47.84" / 105° 11' 35.36"
UBM – 15	Big Muddy Creek: below East Redstone Road bridge	T35N R52E S5 NE ¼	
UBM - 20	Beaver Creek: Dutch Henry Rd. crossing	T37N R52E S25 SW ¼	48° 55' 49.98" / 104° 56' 33.08"

RESULTS

Habitat Assessment

Table 2 shows the habitat measures evaluated, scores, and overall habitat evaluations for the sites studied. Figure 1 displays habitat assessment scores based on these evaluations for the twelve sites on Big Muddy Creek.

Sites in the upper Big Muddy reach tended to have higher overall habitat assessment scores than those in either the lower or middle reaches. The average score for sites in the upper reach was 73% of maximum, while scores in both the lower and middle reaches averaged 66%. Still, the site with the highest overall habitat assessment score was site MBM-10 in the middle reach. Habitat at site MBM-10 was judged optimal, while scores at the eleven other sites on Big Muddy Creek indicated sub-optimal habitat conditions.

Although every individual habitat measure varied considerably throughout the studied length of Big Muddy Creek, there were some general downstream-to-upstream trends in some of the measures. Fine sediment deposition was generally less prevalent at sites in upper Big Muddy Creek than in sites in the lower and middle reaches. In addition, the perceived pool variability was greater in the upper reach.

Figure 1. Total habitat assessment scores, expressed as percent of maximum possible score, for twelve sites on Big Muddy Creek, June 2000.

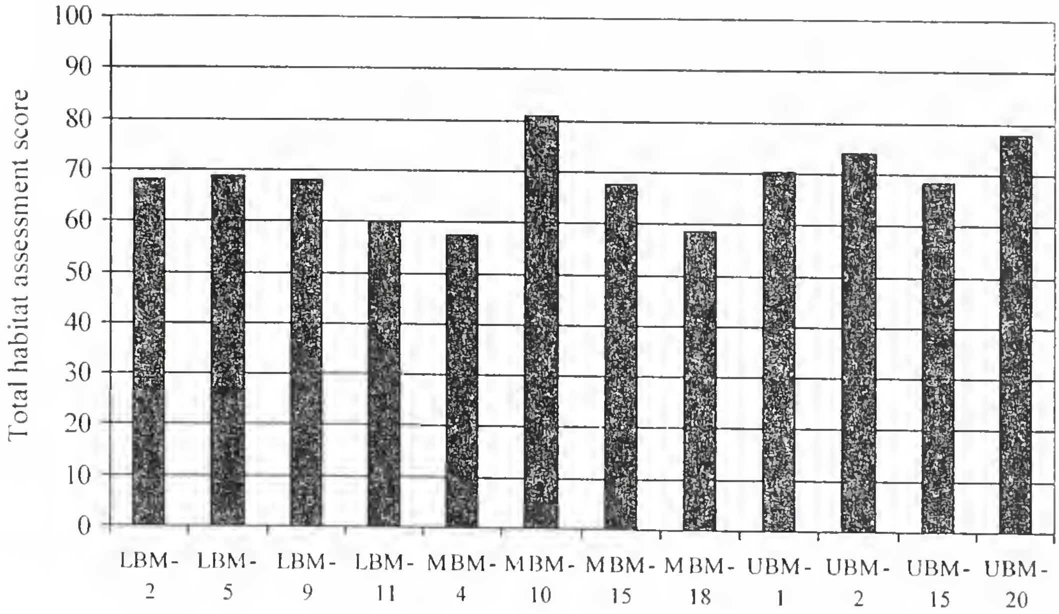


Table 2. Habitat assessment results for twelve sites on Big Muddy Creek, June 2000. Site descriptions are given in Table 1. Field forms for locations marked with an asterisk were not scored, but descriptions of habitat measures were given by field personnel, and scoring categories indicated. In those cases, assigned scores were the highest scores available in the indicated scoring category.

Maximum possible score	Location:	**LBM 2***	**LBM 5***	**LBM 9***	**LBM 11**	**MBM 4**	**MBM 10**	**MBM 15**	**MBM 18**	**UBM 1**	**UBM 2**	**UBM 15**	**UBM 20**
20	Bottom substrate, cover	5	10	15	5	8	16	11	10	4	8	10	14
20	Pool substrate character	15	16	10	8	7	14	12	12	7	15	10	14
20	Pool variability	5	5	5	12	12	10	11	12	13	13	13	16
20	Channel alteration	15	15	20	18	16	20	18	8	19	19	13	12
20	Sediment deposition	10	15	10	10	8	16	14	16	13	17	19	18
20	Channel sinuosity	20	10	10	10	18	15	12	10	13	8	10	8
20	Channel flow status	20	20	20	17	10	19	17	18	16	16	18	18
10 / 10	Bank vegetation protection (left/right)	8 / 8	10/10	8 / 8	8 / 8	7 / 5	10/10	9 / 9	8 / 6	10/10	10 / 9	10/10	10/10
10 / 10	Bank stability (left/right)	10/10	9 / 9	10/10	10/10	9 / 7	9 / 9	9 / 9	7 / 6	10/10	9 / 9	10/10	10/10
10 / 10	Riparian vegetation zone width (left/right)	5 / 5	6 / 3	5 / 5	2 / 2	5 / 3	7 / 7	2 / 2	3 / 1	8 / 8	8 / 7	2 / 2	8 / 8
200	**TOTAL:**	136	138	136	120	115	162	135	117	141	148	137	156
PERCENT OF MAXIMUM:		68	69	68	60	57.5	81	67.5	58.5	70.5	74	68.5	78
CONDITION[1]		SUB	SUB	SUB	SUB	SUB	OPT	SUB	SUB	SUB	SUB	SUB	SUB

[1] OPT = Optimal >81%, SUB = Sub-Optimal 75-56%, Marginal 49-29%, Poor <23%. (Plafkin et al. 1989).

Bioassessment

Macroinvertebrate taxa lists, metric results and other information for each sample are given in the Appendix.

The Montana Plains Ecoregions Reference

Figure 2 compares the total bioassessment scores for the twelve Big Muddy Creek sites using the Montana plains ecoregions reference, the integrated and summed metrics developed by Montana DEQ for the plains ecoregions of the state. As described in the introduction to this report, bioassessment metrics for these ecoregions have not been established definitively, since their performance has not yet been examined thoroughly enough to determine whether or not the individual metrics or their integrated scores can discriminate impaired conditions from good biotic health.

Figure 2. Total bioassessment scores, based on Montana DEQ's Montana plains ecoregion reference, for twelve sites on Big Muddy Creek, June 2000. Scores are expressed as percent of maximum possible score.

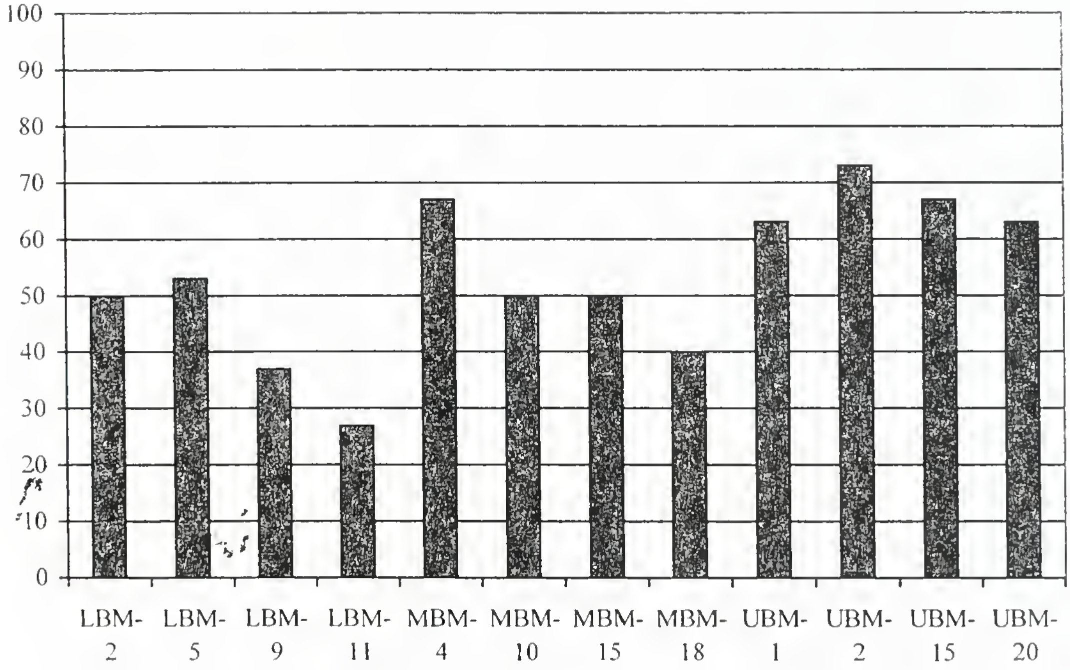


Table 3 summarizes the metric battery and scoring criteria used in the plains ecoregional reference method recommended by Montana DEQ, and Table 4 shows criteria for assignment of use-support categories. Breakdown of scores for each metric calculated from the Big Muddy Creek samples is presented in Table 5.

Bioassessment scores calculated from the metrics used in this method suggest that all sites on Big Muddy Creek violate water and/or habitat quality standards, and that designated uses are partially supported. The protocol would categorize all studied sites on Big Muddy Creek as moderately impaired. There appears to be a general trend for improvement in bioassessment scores in a downstream-to-upstream direction. Site MBM-4 is unusual among lower and middle reach sites; the bioassessment score calculated for that community was as high as the scores calculated for communities in the upper reach of Big Muddy Creek.

The lowest bioassessment score was calculated for the assemblage sampled at LBM-11, the uppermost site in the lower reach. The highest score was calculated for the assemblage sampled at UBM-2, upstream of Plentywood.

Table 3. Metrics and scoring criteria for the Montana plains ecoregions. (From Bukantis, 1998).

	Score			
Metric	**3**	**2**	**1**	**0**
Taxa richness	>24	24 - 18	18 – 12	<12
EPT richness	>8	8 – 6	5 – 3	<3
Biotic Index	<5	5 – 6	6 – 7	>7
% Dominant taxon	<30	30 – 45	45 – 60	>60
% Collectors	<60	60 – 80	80 – 95	>95
% EPT	>50	50 – 30	30 – 10	<10
Shannon H (log2)	>3.0	3.0 – 2.4	2.4 – 1.8	<1.8
% Scrapers + shredders	>30	30 – 15	15 – 3	<3
# Predator taxa	>5	4 – 5	3 – 4	<3
% Multivoltine	<40	40 - 60	60 – 80	>80

Table 4. Criteria for the assignment of support classifications / standards violation thresholds (Bukantis, 1998)

% Comparability to reference	**Use support**
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

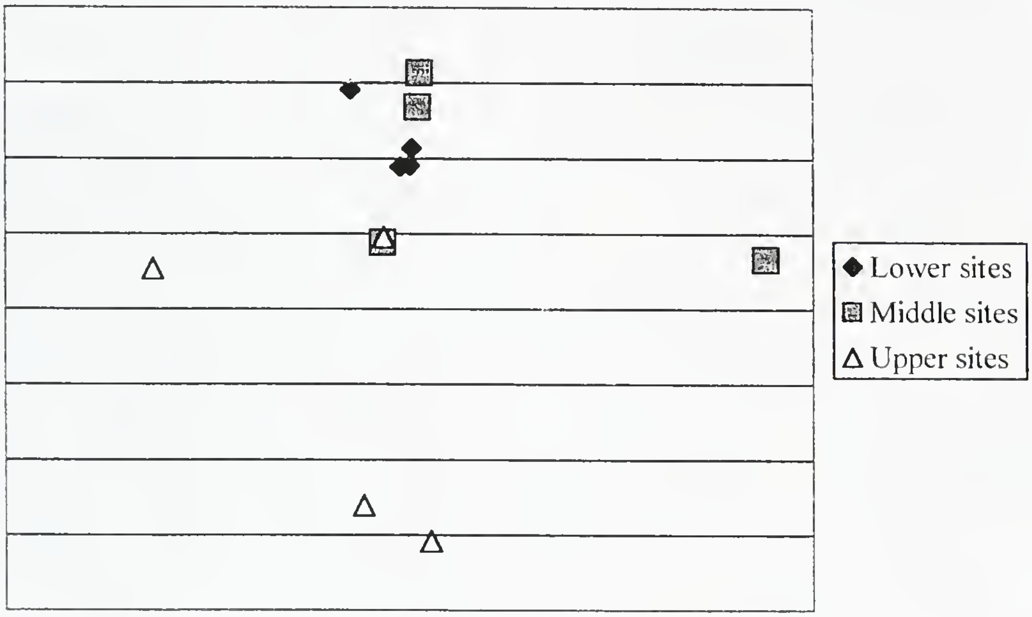
Table 5. Bioassessment metric values and scores. and use support designations for twelve sites on Big Muddy Creek, June 2000.

VALUES	LBM-2	LBM-5	LBM-9	LBM-11	MBM-4	MBM-10	MBM-15	MBM-18	UBM-1	UBM-2	UBM-15	UBM-20
Taxa richness	17	16	14	11	30	29	23	16	35	34	25	31
EPT richness	2	1	0	0	3	5	3	2	4	6	3	5
Biotic Index	8.00	8.09	7.34	8.01	7.39	7.18	7.17	6.45	6.75	6.38	7.02	6.82
% dominant taxon	34	24	32	74	28	49	34	51	35	20	24	44
% collectors	19	26	89	7	60	34	62	39	46	69	55	73
% EPT	9	2	0	0	10	8	2	2	13	40	13	47
Shannon diversity	3.14	3.21	2.82	1.61	3.16	2.32	2.91	2.77	3.03	3.46	3.15	2.76
% Shredders + scrapers	0	0	0	0	3	1	13	0	1	2	2	0
# Predator taxa	7	7	5	4	11	10	4	3	11	10	8	12
% Multivoltine	8	8	3	1	14	6	31	10	43	34	30	13
SCORES												
Taxa richness	1	1	1	0	3	3	2	1	3	3	3	3
EPT richness	0	0	0	0	1	1	1	0	1	2	1	1
Biotic Index	0	0	0	0	0	0	0	1	1	1	0	1
% dominant taxon	2	3	2	0	3	1	2	1	2	3	3	2
% collectors	3	3	1	3	2	3	2	3	3	2	3	2
% EPT	0	0	0	0	1	0	0	0	1	2	1	2
Shannon diversity	3	3	2	0	3	1	2	2	3	3	3	2
% Shredders + scrapers	0	0	0	0	1	0	1	0	0	0	0	0
# Predator taxa	3	3	2	2	3	3	2	1	3	3	3	3
% Multivoltine	3	3	3	3	3	3	3	3	2	3	3	3
TOTAL SCORE	15	16	11	8	20	15	15	12	19	22	20	19
PERCENT MAXIMUM	50	53	37	27	67	50	50	40	63	73	67	63
USE SUPPORT	PART	PART	PART	PART	PART	PART	PART	PART	PART	PART	PART	PART

Invertebrate communities

Figure 3 is an ordination plot of the invertebrate assemblages collected at the twelve sites on Big Muddy Creek, using the sites-by-taxa matrix and a principal components statistical test, which results in a clustering of sites with similar communities, and separation of sites with dissimilar communities. The resulting plot shows a tight clustering of most lower and middle reach sites, and a single upper reach site, UBM-15, suggesting a high degree of assemblage similarity among these sites. Site MBM-4 appears to be unique among Big Muddy Creek sites, as does site UBM-20. The other two upper reach sites, UBM-1 and UBM-2 are similar to each other, but together they are distinct from all other Big Muddy Creek sites.

Figure 3. Ordination of invertebrate assemblages collected from twelve sites on Big Muddy Creek, June 2000.



Invertebrate assemblages of the lower reach of Big Muddy Creek are characterized by low taxa richness; the average number of taxa taken at these sites was 15. Generally, the fauna is dominated by animals that do not live in intimate association with the substrate. This likely corresponds to the observations made by field personnel that substrate was predominantly "muck", mud, or other fine material. Benthic forms were not entirely absent, however. Larvae of the midge *Chironomus* sp. was present in samples taken at three out of four of the lower reach sites. *Glyptotendipes* sp. and *Cryptochironomus* sp. were also present in these samples. None of them were particularly abundant. These midge larvae are associated with detritus and soft sediments, and are characteristic of low dissolved oxygen conditions. Commonly called "bloodworms", these three midge genera carry hemoglobin in their circulating fluids, which enables them to inhabit near-anaerobic habitats. While water column oxygen conditions were reported to be low (see Figure A-1) at only a single site (LBM-5 at Farley Crossing), the presence of these midges suggests that abundant organic material in sediments has resulted in deoxygenated conditions in the substrate.

The fauna in the lower reach of Big Muddy Creek was generally dominated by forms associated either with the water surface, such as the corixids (there were at least 8 different species of this insect family in these samples) and dytiscid beetles, or with emergent vegetation, such as damselfly larvae, snails, the mayflies *Caenis latipennis* and *Callibaetis* sp., and amphipods. Dominance of these animals results in high biotic index scores, since these animals tend to be tolerant of water quality perturbations, such as organic or nutrient pollution, or warm water temperatures. Biotic index values for the lower reach of Big Muddy Creek averaged 7.86, which is judged poor (Table 3), suggesting that diminished water quality may impair the lower reach. Both mayflies collected in this reach prefer sluggish currents and organically enriched silt substrates. Long-lived taxa were generally less common in the lower reach than in either of the other two reaches studied. This suggests that there may be factors or events that interrupt lengthy life cycles, such as periodic dewatering or temperature elevation.

Although the aquatic assemblages of two sites in the middle reach of Big Muddy Creek (MBM-10 at Lower Wolf Creek and MBM-15 below Otter Creek) clustered with the assemblages of the lower reach in the ordination of Figure 3, it is apparent from the data that the addition of many taxa enhances the diversity of all middle reach sites. Taxa richness averaged 25 among these four sites. The increased faunal diversity suggests increased habitat diversity, as does the increase in the number of predator taxa in some of the samples from the middle reach. While animals associated with the water surface and emergent vegetation comprise a considerable proportion of these assemblages, there is an increased occurrence of benthic taxa, suggesting that hard substrate material is more common in the middle reach of Big Muddy Creek than in the lower reach. "Clinger" taxa are quite common in this reach, and include two rhyacophilid caddisflies, the blackfly *Simulium* sp., and the midges *Tanytarsus* sp. and *Cricotopus*, which is represented by several species in these samples.

Similar to the lower reach, sediments appeared to be anaerobic in the two downstream sites in the middle reach, MBM-4 and MBM-10. Hemoglobin-carrying midges in these assemblages included *Endochironomus* sp. and *Dicrotendipes* sp. However, the two upstream sites, no "bloodworm" – type midge taxa were collected, suggesting that sediments were better oxygenated. In addition, lower biotic index scores (mean = 7.04), and the occurrence of several taxa which are less tolerant of organic or nutrient pollution (e.g. the caddisfly *Rhyacophila narvae*, and the mayfly *Baetis tricaudatus*) suggest that water quality is less impaired generally in the middle reach than in the lower reach.

The greatest faunal diversity in the studied reaches of Big Muddy Creek occurred at the sites in the upper reach, where taxa richness averaged 31 among the four sites. This finding, along with the prevalence of predatory taxa, suggests that habitat diversity for invertebrates was better in the upper reach than in either the middle or lower reaches. Long-lived taxa were abundantly represented in these samples, suggesting that flow and thermal conditions may be more stable here than in the lower reach. Although anaerobic sediments persist in the upper reach, biotic index values were lowest of all reaches, averaging 6.74. Even below the Plentywood water treatment lagoons (site UBM-1), the biotic index value (6.75) was no higher than at other sites in the reach. Chironomid abundance was quite high at that site, however; midges comprised nearly half of all animals collected there. Mayflies were numerically abundant at all sites in the upper reach. Mayfly taxa richness is positively associated with water quality; while the value was modest in the upper reach (5 mayfly taxa were collected in the upper reach), it was higher than in either of the other two Big Muddy Creek reaches.

DISCUSSION

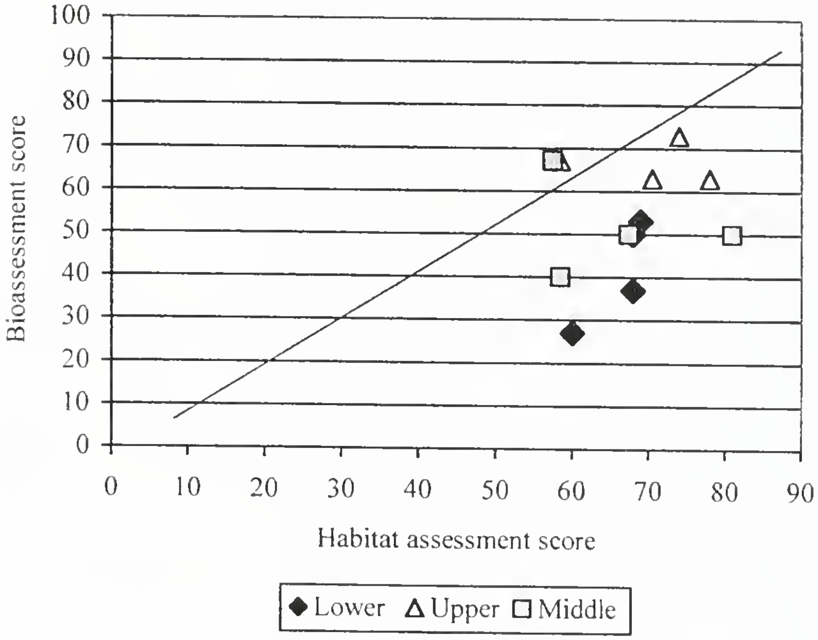
A severe limitation to the usefulness of Montana DEQ's bioassessment metric battery in the plains ecoregions is the stress that it places on the contribution of benthic fauna; this may jeopardize its accuracy in situations where the fauna is more strongly associated with the water surface or with emergent vegetation. The metrics recommended by the State emphasize mayfly, stonefly, and caddisfly richness and the proportion of these insects in assemblages. In addition, the functional feeding group metrics in the current battery, which measure the proportion of scrapers, collectors, and filter feeders, generally stress animals dependent upon hard substrates, such as gravels and cobbles. Out of the ten recommended metrics in the plains ecoregions protocol, four relate either to the "EPT" fauna or to feeding functions dependent on hard substrates. While gravel and cobble substrates are not unknown in the plains ecoregions, the more common circumstances are mud, sand, or "mucky" substrates. Whether or not these substrates represent "natural" conditions is unclear. Confidence in bioassessment protocols will require further study; efforts should be made to determine habitat measures that are associated with both human disturbance and with biotic communities.

CONCLUSIONS

- High biotic index values, as well as the taxonomic composition of the invertebrate assemblage suggest that water quality impairment affects biotic health in the lower reaches of Big Muddy Creek. Low taxa richness suggests that habitat is limited in this reach. The relatively low number of long-lived taxa may indicate that the reach is periodically dewatered, or that thermal or other physical impairment may periodically interrupt the life cycles of some animals.
- Lower biotic index values, and higher taxa richness suggest that both habitat and water quality is better in the middle reach than in the lower reach. The appearance of a few "clinger" taxa indicates that some hard substrate material adds to habitat diversity in this reach.
- Both water quality and habitat conditions improve in the upper reach of Big Muddy Creek, where faunal diversity is most developed. Lower biotic index values and modest gain in mayfly taxa richness suggest that water quality only mildly limits biotic health here.
- Anaerobic substrates persist from the lower reach of Big Muddy Creek at least up to the site above Plentywood. Faunal indicators for this condition are not present at sites UBM-15 or UBM-20.

The relationship between habitat assessment scores and bioassessment scores suggests that water quality was a limiting factor to the biotic health of the benthic community in Big Muddy Creek at many sites. Figure 4 illustrates these relationships. Points representing all of the lower reach sites, three of the middle reach sites and at least one of the upper reach sites lie below a line describing the expected relationship between habitat and biotic health when water quality is unimpaired. For these sites, habitat assessment scores are lower than the corresponding bioassessment scores, suggesting that a factor in addition to low habitat quality further impairs biotic health. This additional factor is presumed to be impaired water quality. In contrast, the points representing sites MBM-4 and UBM-15 (which overlie one another) are positioned above the line, where their moderately high habitat assessment scores are coupled with moderately high bioassessment scores. For these sites, as well as for the other upper reach sites lying near the line, habitat quality appears to be the main influence on biotic health.

Figure 4. Total bioassessment scores plotted against habitat assessment scores for twelve sites on the Big Muddy Creek, June 2000. The red line describes the hypothetical relationship expected when water quality is good and biotic health is determined predominantly by habitat quality (Barbour et al. 1999).



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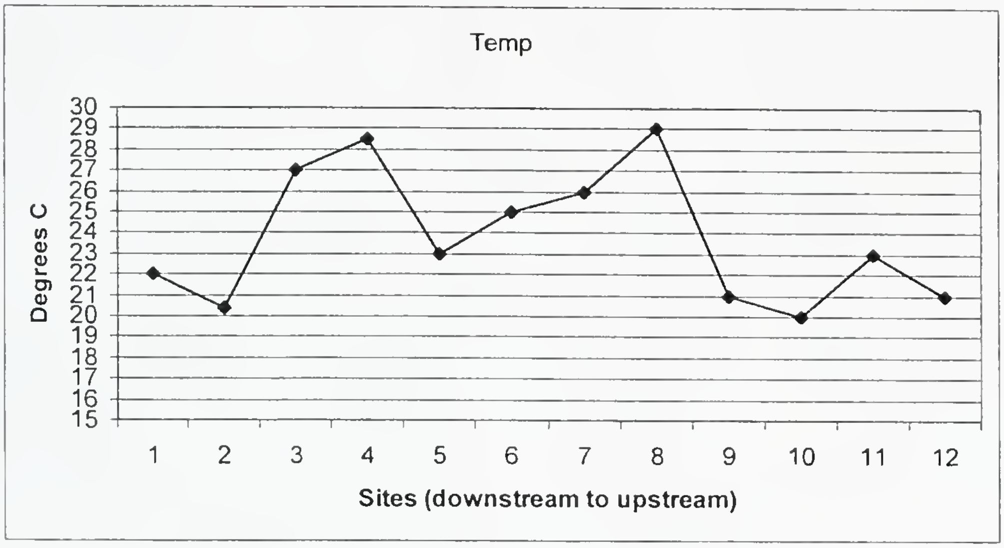
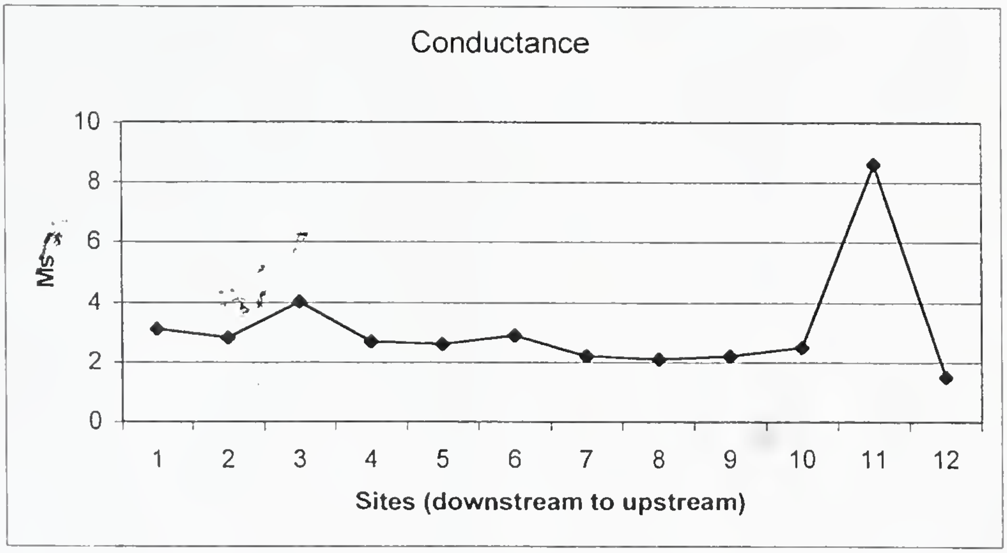
APPENDIX

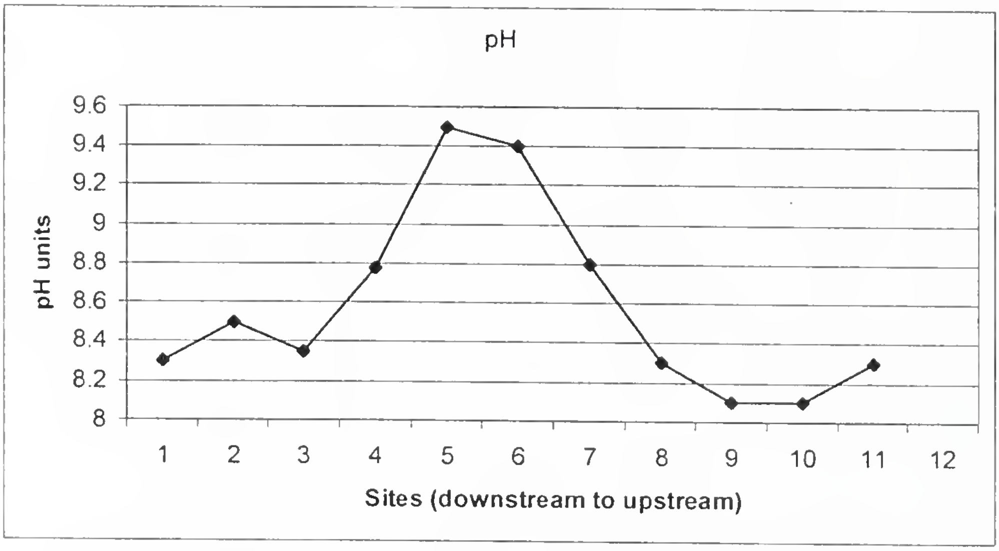
Big Muddy Creek, June 2000

1. Graphs of physical and chemical measurements
2. Macroinvertebrate taxa lists and metric data

1. Graphs of physical and chemical measurements



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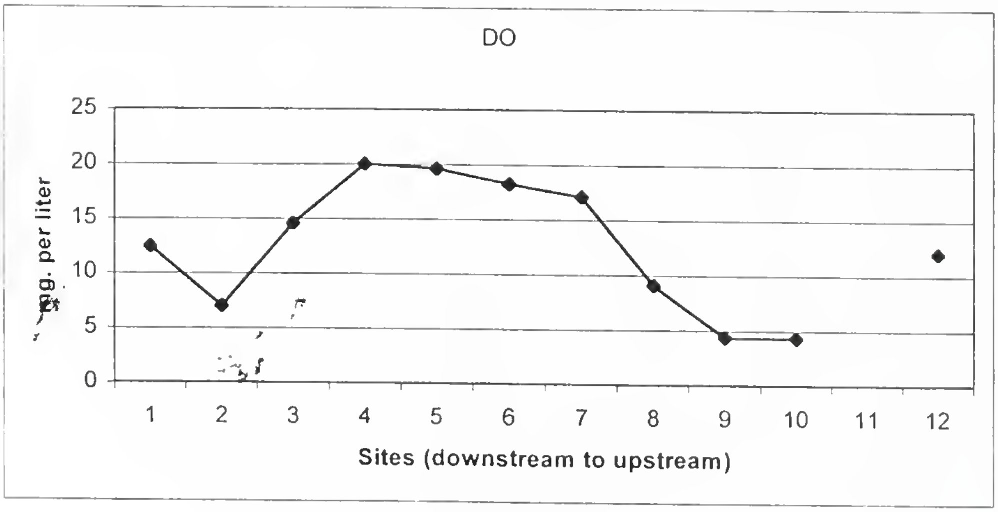
Sites (downstream to upstream)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12
Sites (downstream to upstream)

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Big Muddy (Robert Olsen)
Site ID: LBM - 2

Approx. percent of sample used: entire

Taxon	**Quantity**	**Percent**	**HBI**	**FFG**
Physidae	1	1.05	8	CG
Cladocera	1	1.05	8	CF
Hyalella azteca	1	1.05	8	CG
Total Misc. Taxa	**3**	**3.16**		
Coenagrionidae-early instar	3	3.16	9	PR
Enallagma civile	4	4.21	9	PR
Total Odonata	**7**	**7.37**		
Callibaetis sp.	2	2.11	9	CG
Caenis latipennis	7	7.37	7	CG
Total Ephemeroptera	**9**	**9.47**		
Corixidae - immature	20	21.05	8	UN
Palmacorixa gilletti	32	33.68	8	PH
Sigara alternata	1	1.05	8	PH
Trichocorixa borealis	10	10.53	8	PR
Buenoa sp.	1	1.05	11	PR
Total Hemiptera	**64**	**67.37**		
Dubiraphia sp.	2	2.11	6	CG
Gyrinus sp.	2	2.11	8	PR
Berosus sp.	1	1.05	5	PR
Total Coleoptera	**5**	**5.26**		
Glyptotendipes sp.	4	4.21	10	CG
Larsia sp.	1	1.05	6	PR
Paratanytarsus sp.	1	1.05	6	UN
Polypedilum sp.	1	1.05	6	OM
Total Chironomidae	**7**	**7.37**		
Grand Total	95	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Big Muddy (Robert Olsen)

TOTAL ABUNDANCE	95
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	9
TOTAL NUMBER OF TAXA	19
Number EPT taxa	2

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	3	3	3.16
Odonata	2	7	7.37
Ephemeroptera	2	9	9.47
Plecoptera	0	0	0.00
Hemiptera	5	64	67.37
Megaloptera	0	0	0.00
Trichoptera	0	0	0.00
Lepidoptera	0	0	0.00
Coleoptera	3	5	5.26
Diptera	0	0	0.00
Chrionomidae	4	7	7.37

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	1.29

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	7	22	23.16
Parasite	0	0	0.00
Collector-gatherer	6	17	17.89
Collector-filterer	1	1	1.05
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	2	33	34 74
Scraper	0	0	0.00
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	1	1	1.05
Unknown	2	21	22.11

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.00
Scraper/(Scraper + C.filterer)	0.00
Shredder/Total organisms	0.00

Site ID: LBM - 2

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Palmacorixa gilletti	32	33.68
Corixidae - immature	20	21.05
Trichocorixa borealis	10	10.53
Caenis latipennis	7	7.37
Enallagma civile	4	4.21
SUBTOTAL 5 DOMINANTS	73	76.84
Glyptotendipes sp.	4	4.21
Coenagrionidae-early instar	3	3.16
Callibaetis sp.	2	2.11
Dubiraphia sp.	2	2.11
Gyrinus sp.	2	2.11
TOTAL DOMINANTS	86	90.54

SAPROBIC INDICES

Hilsenhoff Biotic Index	8.00

DIVERSITY MEASURES

Shannon H (loge)	2.17
Shannon H (log2)	3.14
Evenness	0.74
Simpson D	0.17

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	8	8.16
Univoltine	82	86.58
Semivoltine	5	5.26

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	20	21.05
Intolerant	0	0	0.00
Clinger	1	2	2.11

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Farley Crossing
Site ID: LBM - 5

Approx. percent of sample used: entire

Taxon	Quantity	Percent	HBI	FFG
Mooreobdella sp.	1	0.63	6	PR
Pelecypoda	1	0.63	11	CF
Cladocera	2	1.25	8	CF
Hyalella azteca	21	13.13	8	CG
Total Misc. Taxa	**25**	**15.63**		
Enallagma geminatum	1	0.63	8	PR
Enallagma civile	9	5.63	9	PR
Total Odonata	**10**	**6.25**		
Caenis latipennis	4	2.50	7	CG
Total Ephemeroptera	**4**	**2.50**		
Corixidae - immature	4	2.50	8	UN
Hesperocorixa laevigata	3	1.88	8	PR
Palmacorixa buenoa	32	20.00	8	PH
Palmacorixa gilletti	2	1.25	8	PH
Sigara lineata	21	13.13	8	PH
Trichocorixa borealis	38	23.75	8	PR
Total Hemiptera	**100**	**62.50**		
Berasus sp.	6	3.75	5	PR
Total Coleoptera	**6**	**3.75**		
Chironomus sp.	12	7.50	10	CG
Cryptochironomus sp.	2	1.25	8	PR
Glyptotendipes sp.	1	0.63	10	CG
Total Chironomidae	**15**	**9.38**		
Grand Total	**160**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Farley Crossing

Site ID: LBM - 5

TOTAL ABUNDANCE	160
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	4
TOTAL NUMBER OF TAXA	17
Number EPT taxa	1

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	4	25	15.63
Odonata	2	10	6.25
Ephemeroptera	1	4	2.50
Plecoptera	0	0	0.00
Hemiptera	6	100	62.50
Megaloptera	0	0	0.00
Trichoptera	0	0	0.00
Lepidoptera	0	0	0.00
Coleoptera	1	6	3.75
Diptera	0	0	0.00
Chrionomidae	3	15	9.38

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.27

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	7	60	37.50
Parasite	0	0	0.00
Collector-gatherer	4	38	23.75
Collector-filterer	2	3	1.88
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	3	55	34.38
Scraper	0	0	0.00
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	0	0	0.00
Unknown	1	4	2.50

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.00
Scraper/(Scraper + C.filterer)	0.00
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Trichocorixa borealis	38	23.75
Palmacorixa buenoa	32	20.00
Hyalella azteca	21	13.13
Sigara lineata	21	13.13
Chironomus sp.	12	7.50
SUBTOTAL 5 DOMINANTS	124	77.50
Enallagma civile	9	5.63
Berosus sp.	6	3.75
Caenis latipennis	4	2.50
Corixidae - immature	4	2.50
Hesperocorixa laevigata	3	1.88
TOTAL DOMINANTS	150	93.76

SAPROBIC INDICES

Hilsenhoff Biotic Index	8.09

DIVERSITY MEASURES

Shannon H (loge)	2.23
Shannon H (log2)	3.21
Evenness	0.79
Simpson D	0.14

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	13	8.28
Univoltine	140	87.50
Semivoltine	7	4.22

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	46	28.75
Intolerant	0	0	0.00
Clinger	0	0	0.00

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Manning Lake Creek

Site ID: LBM - 9

Approx. percent of sample used: entire

Taxon	**Quantity**	**Percent**	**HBI**	**FFG**
Tubificidae - immature	1	0.58	9	CG
Fossoria sp.	32	18.71	6	CG
Stagnicolo sp.	3	1.75	6	CG
Physidae	55	32.16	8	CG
Gammarus sp.	20	11.70	6	CG
Hyalella azteca	34	19.88	8	CG
Total Misc. Taxa	**145**	**84.80**		
Sympetrum internum	5	2.92	9	PR
Lestes congener	1	0.58	9	PR
Total Odonata	**6**	**3.51**		
Corixidae - immature	3	1.75	8	UN
Sigara grossolineata	4	2.34	8	PH
Total Hemiptera	**7**	**4.09**		
Hydrophilidae - early instar larvae	1	0.58	5	PR
Berosus sp.	4	2.34	5	PR
Total Coleoptera	**5**	**2.92**		
Dixella sp.	1	0.58	2	CG
Total Diptera	**1**	**0.58**		
Chironomus sp.	5	2.92	10	CG
Cryptochironomus sp.	1	0.58	8	PR
Procladius sp.	1	0.58	9	CG
Total Chironomidae	**7**	**4.09**		
Grand Total	**171**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Manning Lake Creek

Site ID: LBM - 9

TOTAL ABUNDANCE	171
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	0
TOTAL NUMBER OF TAXA	16
Number EPT taxa	0

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	6	145	84.80
Odonata	2	6	3.51
Ephemeroptera	0	0	0.00
Plecoptera	0	0	0.00
Hemiptera	2	7	4.09
Megaloptera	0	0	0.00
Trichoptera	0	0	0.00
Lepidoptera	0	0	0.00
Coleoptera	2	5	2.92
Diptera	1	1	0.58
Chrionomidae	3	7	4.09

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.00

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	5	12	7.02
Parasite	0	0	0.00
Collector-gatherer	9	152	88.89
Collector-filterer	0	0	0.00
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	1	4	2.34
Scraper	0	0	0.00
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	0	0	0.00
Unknown	1	3	1.75

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	#DIV/0!
Scraper/(Scraper + C.filterer)	#DIV/0!
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Physidae	55	32.16
Hyalella azteca	34	19.88
Fossaria sp.	32	18.71
Gammarus sp.	20	11.70
Sympetrum internum	5	2.92
SUBTOTAL 5 DOMINANTS	146	85.38
Chironomus sp.	5	2.92
Sigara grossolineata	4	2.34
Berosus sp.	4	2.34
Stagnicola sp.	3	1.75
Corixidae - immature	3	1.75
TOTAL DOMINANTS	19	11.11

SAPROBIC INDICES

Hilsenhoff Biotic Index	7.34

DIVERSITY MEASURES

Shannon H (loge)	1.96
Shannon H (log2)	2.82
Evenness	0.71
Simpson D	0.19

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	5	3.07
Univoltine	156	91.08
Semivoltine	10	5.85

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	156	91.23
Intolerant	0	0	0.00
Clinger	0	0	0.00

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Jim Anderson above slab

Site ID: LBM - 11 Approx. percent of sample used: entire

Taxon	**Quantity**	**Percent**	**HBI**	**FFG**
Tubificidae - immature	2	1.63	9	CG
Copepoda	1	0.81	8	CG
Hyalella azteca	2	1.63	8	CG
Total Misc. Taxa	**5**	**4.07**		
Enallagma civile	4	3.25	9	PR
Total Odonata	**4**	**3.25**		
Corixidae - immature	4	3.25	8	UN
Palmacorixa buenoa	2	1.63	8	PR
Sigara bicolorpennis	2	1.63	8	PH
Sigora alternata	11	8.94	8	PH
Trichocorixa borealis	91	73.98	8	PR
Total Hemiptera	**110**	**89.43**		
Rhantus wallisi	1	0.81	5	PR
Dubiraphia sp.	2	1.63	6	CG
Total Coleoptera	**3**	**2.44**		
Chironomus sp.	1	0.81	10	CG
Total Chironomidae	**1**	**0.81**		
Grand Total	**123**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Jim Anderson above slab

TOTAL ABUNDANCE	123
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	0
TOTAL NUMBER OF TAXA	12
Number EPT taxa	0

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	3	5	4.07
Odonata	1	4	3.25
Ephemeroptera	0	0	0.00
Plecoptera	0	0	0.00
Hemiptera	5	110	89.43
Megaloptera	0	0	0.00
Trichoptera	0	0	0.00
Lepidoptera	0	0	0.00
Coleoptera	2	3	2.44
Diptera	0	0	0.00
Chrionomidae	1	1	0.81

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.00

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	4	98	79.67
Parasite	0	0	0.00
Collector-gatherer	5	8	6.50
Collector-filterer	0	0	0.00
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	2	13	10.57
Scraper	0	0	0.00
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	0	0	0.00
Unknown	1	4	3.25

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	#DIV/0!
Scraper/(Scraper + C.filterer)	#DIV/0!
Shredder/Total organisms	0.00

Site ID: LBM - 11

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Trichocorixa borealis	91	73.98
Sigara alternata	11	8.94
Enallagma civile	4	3.25
Corixidae - immature	4	3.25
Tubificidae - immature	2	1.63
SUBTOTAL 5 DOMINANTS	112	91.06
Hyalella azteca	2	1.63
Palmacorixa buenoa	2	1.63
Sigara bicolorpennis	2	1.63
Dubiraphia sp.	2	1.63
Copepoda	1	0.81
TOTAL DOMINANTS	120	97.56

SAPROBIC INDICES

Hilsenhoff Biotic Index	8.01

DIVERSITY MEASURES

Shannon H (loge)	1.11
Shannon H (log2)	1.61
Evenness	0.45
Simpson D	0.56

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	2	1.42
Univoltine	118	96.14
Semivoltine	3	2.44

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	6	4.88
Intolerant	0	0	0.00
Clinger	1	2	1.63

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Sheridan County Conservation District
Site ID: MBM - 4
Approx. percent of sample used: 17

Taxon	Quantity	Percent	HBI	FFG
Nematoda	1	0.31	5	PA
Tubificidae - immature	4	1.24	9	CG
Aulodrilus pluriseta	3	0.93	9	CG
Alboglossiphonia heteroclita	1	0.31	6	PR
Physidae	90	27.95	8	CG
Promenetus sp.	10	3.11	6	SC
Gammarus sp.	6	1.86	6	CG
Hyalella azteca	55	17.08	8	CG
Acari	26	8.07	5	PA
Total Misc. Taxa	**196**	**60.87**		
Enallagma ebrium	2	0.62	9	PR
Lestes congener	11	3.42	9	PR
Total Odonata	**13**	**4.04**		
Callibaetis sp.	2	0.62	9	CG
Caenis latipennis	27	8.39	7	CG
Total Ephemeroptera	**29**	**9.01**		
Corixidae - immature	8	2.48	8	UN
Sigara decoratella	10	3.11	8	PH
Sigara solensis	2	0.62	8	PH
Trichocorixa borealis	14	4.35	8	PR
Total Hemiptera	**34**	**10.56**		
Rhyacophila Coloradensis Gr.	2	0.62	2	PR
Total Trichoptera	**2**	**0.62**		
Coptotomus longulus	1	0.31	5	PR
Laccophilus biguttatus	1	0.31		PR
Dubiraphia sp.	2	0.62	6	CG
Peltodytes tortulosus	1	0.31	5	MH
Peltodytes edentulus	1	0.31	5	MH
Total Coleoptera	**6**	**1.86**		
Atherix sp.	1	0.31	4	PR
Ceratopogoninae	17	5.28	6	PR
Total Diptera	**18**	**5.59**		
Cryptotendipes sp.	1	0.31	6	UN
Endochironomus sp.	2	0.62	10	CG
Paratanytarsus sp.	10	3.11	6	UN
Polypedilum sp.	1	0.31	6	OM
Procladius sp.	3	0.93	9	CG
Tanypus sp.	6	1.86	10	PR
Thienemannimyia Gr.	1	0.31	6	PR
Total Chironomidae	**24**	**7.45**		
Grand Total	**322**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Sheridan County Conservation District

TOTAL ABUNDANCE	322
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	31
TOTAL NUMBER OF TAXA	32
Number EPT taxa	3

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	9	196	60.87
Odonata	2	13	4.04
Ephemeroptera	2	29	9.01
Plecoptera	0	0	0.00
Hemiptera	4	34	10.56
Megaloptera	0	0	0.00
Trichoptera	1	2	0.62
Lepidoptera	0	0	0.00
Coleoptera	5	6	1.86
Diptera	2	18	5.59
Chrionomidae	7	24	7.45

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	1.29

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	11	57	17.70
Parasite	2	27	8.39
Collector-gatherer	10	194	60.25
Collector-filterer	0	0	0.00
Macrophyte-herbivore	2	2	0.62
Piercer-herbivore	2	12	3.73
Scraper	1	10	3.11
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	1	1	0.31
Unknown	3	19	5.90

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	#DIV/0!
Scraper/(Scraper + C.filterer)	1.00
Shredder/Total organisms	0.00

Site ID: MBM - 4

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Physidae	90	27.95
Hyalella azteca	55	17.08
Caenis latipennis	27	8.39
Acari	26	8.07
Ceratopogoninae	17	5.28
SUBTOTAL 5 DOMINANTS	215	66.77
Trichocorixa borealis	14	4.35
Lestes congener	11	3.42
Promenetus sp.	10	3.11
Sigara decoratella	10	3.11
Paratanytarsus sp.	10	3.11
TOTAL DOMINANTS	270	83.85

SAPROBIC INDICES

Hilsenhoff Biotic Index	7.39

DIVERSITY MEASURES

Shannon H (loge)	2.19
Shannon H (log2)	3.16
Evenness	0.63
Simpson D	0.11

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	47	14.44
Univoltine	269	83.39
Semivoltine	7	2.17

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	209	64.91
Intolerant	0	0	0.00
Clinger	3	5	1.55

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Lower Wolf Creek

Site ID: MBM - 10

Approx. percent of sample used: 23

Taxon	**Quantity**	**Percent**	**HB1**	**FFG**
Physidae	6	2.00	8	CG
Hyalella azteca	8	2.67	8	CG
Acari	1	0.33	5	PA
Total Misc. Taxa	**15**	**5.00**		
Enallagma ebrium	2	0.67	9	PR
Total Odonata	**2**	**0.67**		
Baetis tricaudatus	1	0.33	6	CG
Callibaetis sp.	4	1.33	9	CG
Caenis latipennis	16	5.33	7	CG
Total Ephemeroptera	**21**	**7.00**		
Corixidae - immature	147	49.00	8	UN
Sigara grossolineata	1	0.33	8	PH
Trichocorixa borealis	3	1.00	8	PR
Total Hemiptera	**151**	**50.33**		
Limnephilus sp.	1	0.33	3	SH
Rhyacophila narvae	1	0.33	1	PR
Total Trichoptera	**2**	**0.67**		
Hydroporus sp.	12	4.00	5	PR
Rhantus sp. - larvae	3	1.00	5	PR
Dubiraphia sp.	54	18.00	6	CG
Peltodytes edentulus	3	1.00	5	MH
Peltodytes sp. - early instar larvae	2	0.67	5	MH
Berosus sp.	1	0.33	5	PR
Total Coleoptera	**75**	**25.00**		
Ceratopogoninae	14	4.67	6	PR
Tabanidae	1	0.33	8	PR
Total Diptera	**15**	**5.00**		
Cricotopus Tremulus Gr.	1	0.33	7	CG
Dicrotendipes sp.	1	0.33	8	CG
Endochironomus sp.	1	0.33	10	CG
Larsia sp.	1	0.33	6	PR
Orthocladius (Euorthocladius) Group	1	0.33	6	CG
Paratanytarsus sp.	1	0.33	6	UN
Polypedilum sp.	2	0.67	6	OM
Psectrocladius elatus	5	1.67	8	CG
Tanypus sp.	1	0.33	10	PR
Tanytarsus sp.	1	0.33	6	CF
Tvetenia sp.	4	1.33	5	CG
Total Chironomidae	**19**	**6.33**		
Grand Total	**300**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Lower Wolf Creek

Site ID: MBM - 10

TOTAL ABUNDANCE	300
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	23
TOTAL NUMBER OF TAXA	31
Number EPT taxa	5

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	3	15	5.00
Odonata	1	2	0.67
Ephemeroptera	3	21	7.00
Plecoptera	0	0	0.00
Hemiptera	3	151	50.33
Megaloptera	0	0	0.00
Trichoptera	2	2	0.67
Lepidoptera	0	0	0.00
Coleoptera	6	75	25.00
Diptera	2	15	5.00
Chironomidae	11	19	6.33

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	1.21

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	10	39	13.00
Parasite	1	1	0.33
Collector-gatherer	12	102	34.00
Collector-filterer	1	1	0.33
Macrophyte-herbivore	2	5	1.67
Piercer-herbivore	1	1	0.33
Scraper	0	0	0.00
Shredder	1	1	0.33
Xylophage	0	0	0.00
Omnivore	1	2	0.67
Unknown	2	148	49.33

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.00
Scraper/(Scraper + C.filterer)	0.00
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Corixidae - immature	147	49.00
Dubiraphia sp.	54	18.00
Caenis latipennis	16	5.33
Ceratopogoninae	14	4.67
Hydroporus sp.	12	4.00
SUBTOTAL 5 DOMINANTS	243	81.00
Hyalella azteca	8	2.67
Physidae	6	2.00
Psectrocladius elatus	5	1.67
Callibaetis sp.	4	1.33
Tvetenia sp.	4	1.33
TOTAL DOMINANTS	270	89.99

SAPROBIC INDICES

Hilsenhoff Biotic Index	7.18

DIVERSITY MEASURES

Shannon H (loge)	1.61
Shannon H (log2)	2.32
Evenness	0.47
Simpson D	0.22

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	19	6.33
Univoltine	206	68.50
Semivoltine	76	25.17

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	120	40.00
Intolerant	0	0	0.00
Clinger	4	59	19.67

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Below Otter Creek
Site ID: MBM - 15

Approx. percent of sample used: 60

Taxon	Quantity	Percent	HBI	FFG
Naididae	2	0.62	8	CG
Physidae	10	3.12	8	CG
Promenetus sp.	42	13.08	6	SC
Cladocera	33	10.28	8	CF
Copepoda	5	1.56	8	CG
Hyalella azteca	108	33.64	8	CG
Acari	24	7.48	5	PA
Total Misc. Taxa	**224**	**69.78**		
Enallagma ebrium	8	2.49	9	PR
Total Odonata	**8**	**2.49**		
Callibaetis sp.	2	0.62	9	CG
Caenis latipennis	5	1.56	7	CG
Total Ephemeroptera	**7**	**2.18**		
Corixidae - immature	7	2.18	8	UN
Hesperocorixa laevigata	1	0.31	8	PH
Total Hemiptera	**8**	**2.49**		
Agraylea sp.	1	0.31	8	PH
Total Trichoptera	**1**	**0.31**		
Hydroporus sp.	7	2.18	5	PR
Rhantus sp	4	1.25	5	PR
Dubiraphia sp.	3	0.93	6	CG
Haliplus sp.	3	0.93	5	MH
Total Coleoptera	**17**	**5.30**		
Ceratopogoninae	8	2.49	6	PR
Total Diptera	**8**	**2.49**		
Cricotopus (Cricotopus)	1	0.31	7	CG
Paratanytarsus sp.	17	5.30	6	UN
Psectrocladius vernalis	2	0.62	8	CG
Psectrocladius elatus	19	5.92	8	CG
Tanytarsus sp.	7	2.18	6	CF
Thienemanniella sp.	2	0.62	6	CG
Total Chironomidae	**48**	**14.95**		
Grand Total	**321**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Below Otter Creek

TOTAL ABUNDANCE	321
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	8
TOTAL NUMBER OF TAXA	24
Number EPT taxa	3

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	7	224	69.78
Odonata	1	8	2.49
Ephemeroptera	2	7	2.18
Plecoptera	0	0	0.00
Hemiptera	2	8	2.49
Megaloptera	0	0	0.00
Trichoptera	1	1	0.31
Lepidoptera	0	0	0.00
Coleoptera	4	17	5.30
Diptera	1	8	2.49
Chrionomidae	6	48	14.95

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.17

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	4	27	8.41
Parasite	1	24	7.48
Collector-gatherer	11	159	49.53
Collector-filterer	2	40	12.46
Macrophyte-herbivore	1	3	0.93
Piercer-herbivore	2	2	0.62
Scraper	1	42	13.08
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	0	0	0.00
Unknown	2	24	7.48

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	1.05
Scraper/(Scraper + C.filterer)	0.51
Shredder/Total organisms	0.00

Site ID: MBM - 15

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Hyalella azteca	108	33.64
Promenetus sp.	42	13.08
Cladocera	33	10.28
Acari	24	7.48
Psectrocladius elatus	19	5.92
SUBTOTAL 5 DOMINANTS	226	70.40
Paratanytarsus sp.	17	5.30
Physidae	10	3.12
Enallagma ebrium	8	2.49
Ceratopogoninae	8	2.49
Corixidae - immature	7	2.18
TOTAL DOMINANTS	276	85.98

SAPROBIC INDICES

Hilsenhoff Biotic Index	7.17

DIVERSITY MEASURES

Shannon H (loge)	2.02
Shannon H (log2)	2.91
Evenness	0.63
Simpson D	0.13

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	100	31.23
Univoltine	204	63.47
Semivoltine	17	5.30

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	205	63.86
Intolerant	0	0	0.00
Clinger	3	5	1.56

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Rom Hedges
Site ID: MBM - 18

Approx. percent of sample used: entire

Taxon	Quantity	Percent	HBI	FFG
Naididae	3	3.26	8	CG
Pisidium sp.	3	3.26	8	CG
Physidae	5	5.43	8	CG
Hyalella azteca	6	6.52	8	CG
Acari	3	3.26	5	PA
Total Misc. Taxa	**20**	**21.74**		
Callibaetis sp.	1	1.09	9	CG
Caenis latipennis	1	1.09	7	CG
Total Ephemeroptera	**2**	**2.17**		
Palmacorixa gilletti	2	2.17	8	PR
Sigara grossolineata	1	1.09	8	PH
Total Hemiptera	**3**	**3.26**		
Dubiraphia sp.	6	6.52	6	CG
Haliplus sp. - larvae	2	2.17	5	MH
Total Coleoptera	**8**	**8.70**		
Ceratopogoninae	47	51.09	6	PR
Simulium sp.	5	5.43	6	CF
Total Diptera	**52**	**56.52**		
Cricotopus Bicinctus Gr.	1	1.09	7	CG
Labrundinia sp.	1	1.09	7	PR
Tanytarsus sp.	5	5.43	6	CF
Total Chironomidae	**7**	**7.61**		
Grand Total	**92**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Rom Hedges

Site ID: MBM - 18

TOTAL ABUNDANCE	92
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	2
TOTAL NUMBER OF TAXA	16
Number EPT taxa	2

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	5	20	21.74
Odonata	0	0	0.00
Ephemeroptera	2	2	2.17
Plecoptera	0	0	0.00
Hemiptera	2	3	3.26
Megaloptera	0	0	0.00
Trichoptera	0	0	0.00
Lepidoptera	0	0	0.00
Coleoptera	2	8	8.70
Diptera	2	52	56.52
Chrionomidae	3	7	7.61

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.29

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	3	50	54.35
Parasite	1	3	3.26
Collector-gatherer	8	26	28.26
Collector-filterer	2	10	10.87
Macrophyte-herbivore	1	2	2.17
Piercer-herbivore	1	1	1.09
Scraper	0	0	0.00
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	0	0	0.00
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.00
Scraper/(Scraper + C filterer)	0.00
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Ceratopogoninae	47	51.09
Hyalella azteca	6	6.52
Dubiraphia sp.	6	6.52
Physidae	5	5.43
Simulium sp.	5	5.43
SUBTOTAL 5 DOMINANTS	69	75.00
Tanytarsus sp.	5	5.43
Naididae	3	3.26
Pisidium sp.	3	3.26
Acari	3	3.26
Palmacorixa gilletti	2	2.17
TOTAL DOMINANTS	85	92.39

SAPROBIC INDICES

Hilsenhoff Biotic Index	6.45

DIVERSITY MEASURES

Shannon H (loge)	1.92
Shannon H (log2)	2.77
Evenness	0.69
Simpson D	0.28

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	9	9.78
Univoltine	74	79.89
Semivoltine	10	10.33

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	22	23.91
Intolerant	0	0	0.00
Clinger	3	16	17.39

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Big Muddy Creek: about 1 mile below Plentywood lagoon discharge
Site ID: UBM - 1 Approx. percent of sample used: 10

Taxon	**Quantity**	**Percent**	**HBI**	**FFG**
Nematoda	1	0.33	5	PA
Naididae	5	1.66	8	CG
Mooreobdella fervida	1	0.33	10	PR
Pisidium sp.	3	0.99	8	CG
Sphaerium sp.	1	0.33	8	CG
Physidae	4	1.32	8	CG
Promenetus sp.	1	0.33	6	SC
Cladocera	17	5.63	8	CF
Hyalella azteca	5	1.66	8	CG
Acari	1	0.33	5	PA
Total Misc. Taxa	**39**	**12.91**		
Octogamphus severus	2	0.66	4	PR
Enallagma ebrium	2	0.66	9	PR
Total Odonata	**4**	**1.32**		
Callibaetis sp.	1	0.33	9	CG
Procloeon sp.	1	0.33	4	CG
Caenis latipennis	37	12.25	7	CG
Total Ephemeroptera	**39**	**12.91**		
Corixidae - immature	17	5.63	8	UN
Palmacorixa buenaa	1	0.33	8	PR
Palmacorixa gilletti	2	0.66	8	PR
Total Hemiptera	**20**	**6.62**		
Oecetis sp.	1	0.33	8	OM
Total Trichoptera	**1**	**0.33**		
Hydroporus sp. - larva	1	0.33	5	PR
Dubiraphia sp.	26	8.61	6	CG
Gyrinus sp.	2	0.66	8	PR
Haliplus sp. - larva	1	0.33	5	MH
Peltodytes tortulosus	1	0.33	5	MH
Total Coleoptera	**31**	**10.26**		
Ceratopogoninae	21	6.95	6	PR
Total Diptera	**21**	**6.95**		
Corynoneura sp.	3	0.99	7	CG
Cricotopus (Isocladius)	14	4.64	7	CG
Cricotopus Tremulus Gr.	2	0.66	7	CG
Dicrotendipes sp.	11	3.64	8	CG
Endochironomus sp.	5	1.66	10	CG
Limnaphyes sp.	2	0.66	8	CG
Parachironomus sp.	1	0.33	10	PR
Paramerina sp.	1	0.33	6	PR
Paratanytarsus sp.	106	35.10	6	UN
Tanypus sp.	1	0.33	10	PR
Tanytarsus sp.	1	0.33	6	CF
Total Chironomidae	**147**	**48.68**		
Grand Total	**302**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Big Muddy Creek: about 1 mile below Plentywood lagoon discharge **Site ID: UBM - 1**

TOTAL ABUNDANCE	302
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	40
TOTAL NUMBER OF TAXA	36
Number EPT taxa	4

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	10	39	12.91
Odonata	2	4	1.32
Ephemeroptera	3	39	12.91
Plecoptera	0	0	0.00
Hemiptera	3	20	6.62
Megaloptera	0	0	0.00
Trichoptera	1	1	0.33
Lepidoptera	0	0	0.00
Coleoptera	5	31	10.26
Diptera	1	21	6.95
Chrionomidae	11	147	48.68

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.27

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	11	35	11.59
Parasite	2	2	0.66
Collector-gatherer	15	120	39.74
Collector-filterer	2	18	5.96
Macrophyte-herbivore	2	2	0.66
Piercer-herbivore	0	0	0.00
Scraper	1	1	0.33
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	1	1	0.33
Unknown	2	123	40.73

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.06
Scraper/(Scraper + C.filterer)	0.05
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Paratanytarsus sp.	106	35.10
Caenis latipennis	37	12.25
Dubiraphia sp.	26	8.61
Ceratopogoninae	21	6.95
Cladocera	17	5.63
SUBTOTAL 5 DOMINANTS	207	68.54
Corixidae - immature	17	5.63
Cricotopus (Isocladius)	14	4.64
Dicrotendipes sp.	11	3.64
Naididae	5	1.66
Hyalella azteca	5	1.66
TOTAL DOMINANTS	259	85.76

SAPROBIC INDICES

Hilsenhoff Biotic Index	6.75

DIVERSITY MEASURES

Shannon H (loge)	2.10
Shannon H (log2)	3.03
Evenness	0.59
Simpson D	0.13

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	131	43.29
Univoltine	136	45.12
Semivoltine	35	11.59

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	100	33.11
Intolerant	0	0	0.00
Clinger	4	43	14.24

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Upstream from Plentywood
Site ID: UBM - 2 Approx. percent of sample used: 80

Taxon	**Quantity**	**Percent**	**HB1**	**FFG**
Enchytraeidae	1	0.34	10	CG
Naididae	3	1.02	8	CG
Placobdella ornata	1	0.34	6	PR
Pisidium sp.	2	0.68	8	CG
Physidae	20	6.78	8	CG
Promenetus sp	1	0.34	6	SC
Cladocera	9	3.05	8	CF
Hyalella azteca	9	3.05	8	CG
Acari	1	0.34	5	PA
Total Misc. Taxa	**47**	**15.93**		
Aeshna interrupta	2	0.68	5	PR
Enallagma ebrium	3	1.02	9	PR
Enallagma civile	2	0.68	9	PR
Enallagma cyathigerum	1	0.34	9	PR
Lestes congener	5	1.69	9	PR
Total Odonata	**13**	**4.41**		
Procloeon sp.	59	20.00	4	CG
Caenis latipennis	49	16.61	7	CG
Hexagenia limbata	2	0.68	6	CG
Total Ephemeroptera	**110**	**37.29**		
Corixidae - immature	8	2.71	8	UN
Palmacorixa gilletti	3	1.02	8	PR
Sigara solensis	1	0.34	8	PH
Total Hemiptera	**12**	**4.07**		
Lepidastoma sp.-sand case larvae	2	0.68	1	SH
Limnephilus sp.	4	1.36	3	SH
Polycentropus sp.	1	0.34	6	PR
Total Trichoptera	**7**	**2.37**		
Dubiraphia sp.	19	6.44	6	CG
Gyrinus sp.	4	1.36	8	PR
Haliplus sp	1	0.34	5	MH
Total Coleoptera	**24**	**8.14**		
Ceratopogoninae	23	7.80	6	PR
Total Diptera	**23**	**7.80**		
Cricotopus Bicinctus Gr.	2	0.68	7	CG
Dicrotendipes sp.	6	2.03	8	CG
Endochironomus sp.	10	3.39	10	CG
Nanocladius sp.	1	0.34	3	CG
Paratanytarsus sp.	28	9.49	6	UN
Procladius sp.	1	0.34	9	CG
Pseudochironomus sp.	1	0.34	5	CG
Tanytarsus sp.	10	3.39	6	CF
Total Chironomidae	**59**	**20.00**		
Grand Total	**295**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Upstream from Plentywood

Site ID: UBM - 2

TOTAL ABUNDANCE	295
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	117
TOTAL NUMBER OF TAXA	35
Number EPT taxa	6

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	9	47	15.93
Odonata	5	13	4.41
Ephemeroptera	3	110	37.29
Plecoptera	0	0	0.00
Hemiptera	3	12	4.07
Megaloptera	0	0	0.00
Trichoptera	3	7	2.37
Lepidoptera	0	0	0.00
Coleoptera	3	24	8.14
Diptera	1	23	7.80
Chrionomidae	8	59	20.00

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	1.98

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	10	45	15.25
Parasite	1	1	0.34
Collector-gatherer	15	185	62.71
Collector-filterer	2	19	6.44
Macrophyte-herbivore	1	1	0.34
Piercer-herbivore	1	1	0.34
Scraper	1	1	0.34
Shredder	2	6	2.03
Xylophage	0	0	0.00
Omnivore	0	0	0.00
Unknown	2	36	12.20

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.05
Scraper/(Scraper + C.filterer)	0.05
Shredder/Total organisms	0.01

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Proclaeon sp.	59	20.00
Caenis latipennis	49	16.61
Paratanytarsus sp.	28	9.49
Ceratopogoninae	23	7.80
Physidae	20	6.78
SUBTOTAL 5 DOMINANTS	179	60.68
Dubiraphia sp.	19	6.44
Endochironomus sp.	10	3.39
Tanytarsus sp.	10	3.39
Cladocera	9	3.05
Hyalella azteca	9	3.05
TOTAL DOMINANTS	236	80.00

SAPROBIC INDICES

Hilsenhoff Biotic Index	6.38

DIVERSITY MEASURES

Shannon H (loge)	2.40
Shannon H (log2)	3.46
Evenness	0.68
Simpson D	0.09

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	99	33.56
Univoltine	168	56.95
Semivoltine	28	9.49

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	124	42.03
Intolerant	0	0	0.00
Clinger	3	31	10.51

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Bridge at Redstone
Site ID: UBM - 15

Approx. percent of sample used: 17

Taxon	Quantity	Percent	HBI	FFG
Naididae	45	13.80	8	CG
Myzobdella lugubris	1	0.31	10	PR
Physidae	24	7.36	8	CG
Promenetus sp.	5	1.53	6	SC
Cladocera	8	2.45	8	CF
Hyalella azteca	33	10.12	8	CG
Acari	11	3.37	5	PA
Total Misc. Taxa	**127**	**38.96**		
Coenagrionidae-early instar	8	2.45	9	PR
Enallagma cyathigerum	2	0.61	9	PR
Enallagma ebrium	5	1.53	9	PR
Total Odonata	**15**	**4.60**		
Procloeon sp.	1	0.31	4	CG
Caenis latipennis	41	12.58	7	CG
Total Ephemeroptera	**42**	**12.88**		
Corixidae - immature	12	3.68	8	UN
Palmacorixa gilletti	6	1.84	8	PR
Total Hemiptera	**18**	**5.52**		
Oxyethira sp.	2	0.61	3	PH
Total Trichoptera	**2**	**0.61**		
Dubiraphia sp.	3	0.92	6	CG
Peltodytes sp. - larvae	3	0.92	5	MH
Peltodytes edentulus	1	0.31	5	MH
Total Coleoptera	**7**	**2.15**		
Ceratopogoninae	11	3.37	6	PR
Tabanidae	1	0.31	8	PR
Total Diptera	**12**	**3.68**		
Corynoneura sp.	1	0.31	7	CG
Cricotopus (Isocladius)	1	0.31	7	CG
Cryptochironomus sp.	1	0.31	8	PR
Nanocladius sp.	2	0.61	3	CG
Paratanytarsus sp.	78	23.93	6	UN
Procladius sp.	1	0.31	9	CG
Psectrocladius elatus	3	0.92	8	CG
Tanytarsus sp.	16	4.91	6	CF
Total Chironomidae	**103**	**31.60**		
Grand Total	**326**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Bridge at Redstone

TOTAL ABUNDANCE	326
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	44
TOTAL NUMBER OF TAXA	28
Number EPT taxa	3

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	7	127	38.96
Odonata	3	15	4.60
Ephemeroptera	2	42	12.88
Plecoptera	0	0	0.00
Hemiptera	2	18	5.52
Megaloptera	0	0	0.00
Trichoptera	1	2	0.61
Lepidoptera	0	0	0.00
Coleoptera	3	7	2.15
Diptera	2	12	3.68
Chironomidae	8	103	31.60

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.43

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	8	35	10.74
Parasite	1	11	3.37
Collector-gatherer	11	155	47.55
Collector-filterer	2	24	7.36
Macrophyte-herbivore	2	4	1.23
Piercer-herbivore	1	2	0.61
Scraper	1	5	1.53
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	0	0	0.00
Unknown	2	90	27.61

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.21
Scraper/(Scraper + C.filterer)	0.17
Shredder/Total organisms	0.00

Site ID: UBM - 15

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Paratanytarsus sp.	78	23.93
Naididae	45	13.80
Caenis latipennis	41	12.58
Hyalella azteca	33	10.12
Physidae	24	7.36
SUBTOTAL 5 DOMINANTS	221	67.79
Tanytarsus sp.	16	4.91
Corixidae - immature	12	3.68
Acari	11	3.37
Ceratopogoninae	11	3.37
Cladocera	8	2.45
TOTAL DOMINANTS	58	17.79

SAPROBIC INDICES

Hilsenhoff Biotic Index	7.02

DIVERSITY MEASURES

Shannon H (loge)	2.19
Shannon H (log2)	3.15
Evenness	0.66
Simpson D	0.10

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	99	30.21
Univoltine	221	67.64
Semivoltine	7	2.15

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	118	36.20
Intolerant	0	0	0.00
Clinger	3	20	6.13

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Beaver Creek: Dutch Henry Rd. crossing: above confl. with Big Muddy Ck.

Site ID: UBM - 20 Approx. percent of sample used: 33

Taxon	**Quantity**	**Percent**	**HBI**	**FFG**
Naididae	3	0.92	8	CG
Erpobdella punctata	1	0.31	10	PR
Mooreobdella sp.	1	0.31	10	PR
Physidae	11	3.38	8	CG
Copepoda	1	0.31	8	CG
Gammarus sp.	2	0.62	6	CG
Hyalella azteca	26	8.00	8	CG
Acari	7	2.15	5	PA
Total Misc. Taxa	**52**	**16.00**		
Aeshnidae-early instar	1	0.31	3	PR
Ophiogomphus severus	1	0.31	4	PR
Enallagma ebrium	1	0.31	9	PR
Total Odonata	**3**	**0.92**		
Baetis intercalaris	4	1.23	5	CG
Caenis latipennis	142	43.69	7	CG
Total Ephemeroptera	**146**	**44.92**		
Corixidae - immature	11	3.38	8	UN
Palmacorixa gilletti	6	1.85	8	PR
Sigara grossolineata	5	1.54	8	PH
Total Hemiptera	**22**	**6.77**		
Cheumatopsyche sp.	2	0.62	8	CF
Hydropsyche sp.	2	0.62	4	CF
Hydroptila sp.	4	1.23	6	PH
Total Trichoptera	**8**	**2.46**		
Hydroporus sp.	2	0.62	5	PR
Dubiraphia sp.	16	4.92	6	CG
Haliplus sp.	3	0.92	5	MH
Total Coleoptera	**21**	**6.46**		
Ceratopogoninae	33	10.15	6	PR
Tabanidae	1	0.31	8	PR
Dicranota sp	2	0.62	3	PR
Total Diptera	**36**	**11.08**		
Cricotopus brevipalpus	1	0.31	7	CG
Cricotopus Tremulus Gr.	2	0.62	7	CG
Cryptochironomus sp.	2	0.62	8	PR
Limnophyes	2	0.62	8	CG
Paratanytarsus sp.	4	1.23	6	UN
Tanytarsus sp.	22	6.77	6	CF
Thienemannimyia Gr.	4	1.23	6	PR
Total Chironomidae	**37**	**11.38**		
Grand Total	**325**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Beaver Creek: Dutch Henry Rd. crossing: above confl. with Big Muddy Ck. **Site ID: UBM - 20**

TOTAL ABUNDANCE	325
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	154
TOTAL NUMBER OF TAXA	32
Number EPT taxa	5

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDANCE	PERCENT
Misc. Taxa	8	52	16.00
Odonata	3	3	0.92
Ephemeroptera	2	146	44.92
Plecoptera	0	0	0.00
Hemiptera	3	22	6.77
Megaloptera	0	0	0.00
Trichoptera	3	8	2.46
Lepidoptera	0	0	0.00
Coleoptera	3	21	6.46
Diptera	3	36	11.08
Chrionomidae	7	37	11.38

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	4.16

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDANCE	PERCENT
Predator	12	55	16.92
Parasite	1	7	2.15
Collector-gatherer	11	210	64.62
Collector-filterer	3	26	8.00
Macrophyte-herbivore	1	3	0.92
Piercer-herbivore	2	9	2.77
Scraper	0	0	0.00
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	0	0	0.00
Unknown	2	15	4.62

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.00
Scraper/(Scraper + C.filterer)	0.00
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Caenis latipennis	142	43.69
Ceratopogoninae	33	10.15
Hyalella azteca	26	8.00
Tanytarsus sp.	22	6.77
Dubiraphia sp.	16	4.92
SUBTOTAL 5 DOMINANTS	239	73.54
Physidae	11	3.38
Corixidae - immature	11	3.38
Acari	7	2.15
Palmacorixa gilletti	6	1.85
Sigara grossolineata	5	1.54
TOTAL DOMINANTS	40	12.31

SAPROBIC INDICES

Hilsenhoff Biotic Index	6.82

DIVERSITY MEASURES

Shannon H (loge)	1.91
Shannon H (log2)	2.76
Evenness	0.55
Simpson D	0.18

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	43	13.15
Univoltine	259	79.77
Semivoltine	23	7.08

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	213	65.54
Intolerant	0	0	0.00
Clinger	7	49	15.08

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A BIOASSESSMENT STUDY OF BIG SPRING CREEK

March, 1999

A report to

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May 2002

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INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected in March 1999 to evaluate the effects of an oil spill on Casino Creek, a stream tributary to Big Spring Creek, Fergus County, Montana. Aquatic invertebrate assemblages were sampled by personnel of the Montana Department of Fish Wildlife and Parks. Study sites lie within the Montana Valley and Foothill Prairies ecoregion. (Woods et al. 1999). A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is " ...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1995). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied is needed to assist in the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat parameters and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998) has recently studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to habitat assessment parameters, and consistent over replicated samples.

Habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by metals, other toxicants, high water temperatures, or high levels of organic and/or nutrient pollution might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment in an oligotrophic setting.

METHODS

Aquatic invertebrates were sampled by Anne Tews, fisheries biologist with Montana Fish Wildlife and Parks in March 1999 at 3 sites on Big Spring Creek. Site locations and sampling dates are indicated in Table 1. The sampling method employed was that recommended in the Montana Department of Environmental Quality (DEQ) Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). In addition to aquatic invertebrate sample collection, habitat quality was visually evaluated at each site and reported by means of the habitat assessment protocols recommended by Bukantis (1998).

Evaluated habitat features include instream conditions, larger-scale channel conditions including flow status, streambank condition, and extent of the riparian zone. Scores were assigned in the field to each habitat measure, and these scores were totaled and compared to the maximum possible score to give an overall assessment of habitat.

Aquatic invertebrate samples and associated habitat data were delivered to Rhithron Biological Associates, Missoula, Montana, for laboratory and data analyses. In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

To assess aquatic invertebrate communities in this study, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998) was used, since these metrics are probably pertinent to the evaluation of Big Spring Creek. Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998). The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics, which have been shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used in this study were selected because both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998). In addition, they are relevant to the kinds of impacts that are present in Big Spring Creek drainage. They have been demonstrated to be more variable with anthropogenic disturbance than with natural environmental gradients (Bollman 1998). Each of the six metrics developed and tested for western Montana ecoregions is described below.

Table 1. Sampling sites and dates: three sites on Big Spring Creek. Sites are listed from upstream to downstream.

Site designation	Site description	Sampling Date	GPS locations Latitude	GPS locations Longitude
1	Tresch: Carroll Trail: downstream of Lewistown	3/8/99	47°04'59"	109°26'56"
2	Dunnington's: Public Bridge: 0.7 miles below confluence of Casino Creek	3/9/99	47°03'20"	109°24'56"
3	Brewery Flats: above Casino Creek confluence	3/8/99	47°02'53"	109°24'43"

1. **Ephemeroptera (mayfly) taxa richness.** The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.
2. **Plecoptera (stonefly) taxa richness.** Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.
3. **Trichoptera (caddisfly) taxa richness.** Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.
4. **Number of sensitive taxa.** Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998).
5. **Percent filter feeders.** Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* spp. and *Parapsyche* sp.) build silken nets with large mesh sizes that

capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

6. **Percent tolerant taxa.** Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

Table 2. Metrics and scoring criteria for bioassessment of streams of western Montana ecoregions (Bollman 1998).

	Score			
metric	**3**	**2**	**1**	**0**
Ephemeroptera taxa richness	> 5	5 – 4	3 – 2	< 2
Plecoptera taxa richness	> 3	3 – 2	1	0
Trichoptera taxa richness	> 4	4 – 3	2	< 2
Sensitive taxa richness	> 3	3 – 2	1	0
Percent filterers	0 – 5	5.01 – 10	10.01 – 25	> 25
Percent tolerant taxa	0 – 5	5.01 – 10	10.01 – 35	> 35

The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman, unpublished data). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.
- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman, unpublished data).
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman, unpublished data).

Table 3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis, 1997).

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table 3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

RESULTS

Habitat assessment

Figure 1 compares habitat assessment results for the 3 sites in this study. Table 4 itemizes the evaluated habitat parameters and shows the assigned scores for each.

Figure 1. Total habitat assessment scores for sites on Big Spring Creek, March 1999. Sites are listed from upstream to downstream.

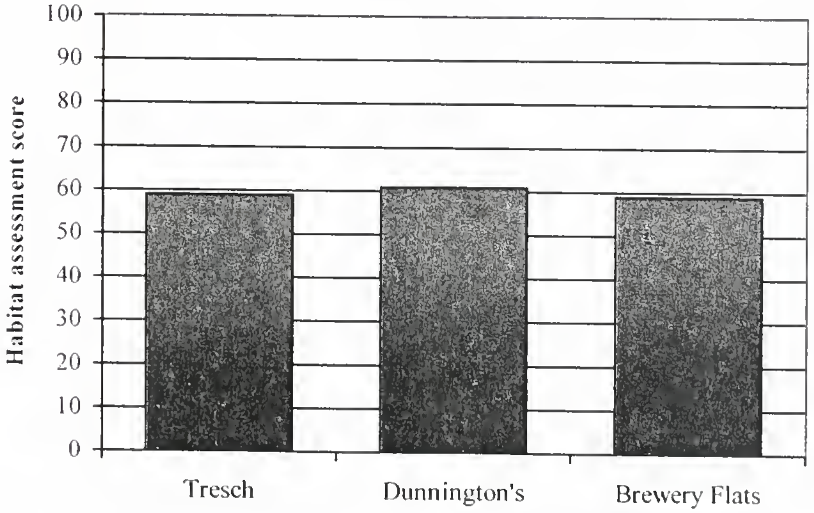

Table 4. Stream and riparian habitat assessment. Big Spring Creek. March 1999.

Max. possible score	**Parameter**	Tresch	Dunnington's	Brewery Flats
10	Riffle development	9	9	7
10	Benthic substrate	3	9	8
20	Embeddedness	7	11	12
20	Channel alteration	12	5	3
20	Sediment deposition	9	11	6
20	Channel flow status	15	17	16
20	Bank stability	6 / 6	8 / 8	7 / 10
20	Bank vegetation	9 / 6	0 / 9	8 / 10
20	Vegetated zone	10 / 2	0 / 10	2 / 6
160	Total	94	97	95
	Percent of maximum	**59**	**61**	**59**
	CONDITION*	**SUB-OPTIMAL**	**SUB-OPTIMAL**	**SUB-OPTIMAL**

*Condition categories: Optimal (OPT) > 80% of maximum score; Sub-optimal (SUB) 75 - 56%; Marginal (MARG) 49 - 29%; Poor <23%. Adapted from Plafkin et al. 1988.

Habitat was judged sub-optimal at all three Big Spring Creek sites.

Bioassessment

Macroinvertebrate taxa lists, metric results, and other information for each sample are given in the Appendix. Figure 2 compares the total bioassessment scores calculated for macroinvertebrate communities collected at each of the three sites. Breakdown of scores for each metric calculated from Big Spring Creek aquatic invertebrate samples is presented in Table 5.

Partial support of designated uses was indicated by bioassessment scores for all three sites on Big Spring Creek, based on this analysis of the aquatic invertebrate assemblages. Scores suggested that biotic health was moderately impaired at Tresch and Brewery Flats and slightly impaired at Dunnington's. At Tresch, all insect richness metrics performed worse than expected. No Plecoptera taxa and no sensitive taxa were collected. The proportion of tolerant taxa exceeded expectations.

The Ephemeroptera taxa richness at Dunnington's was also less than expected, and, similar to the other sites, no sensitive taxa were collected. The proportion of both filter-feeders and tolerant taxa both were greater than expected for a foothills stream.

At Brewery Flats, Ephemeroptera taxa richness was lower than expected, and no sensitive taxa showed up in the sample. Tolerant taxa were more abundant than expected.

Figure 2. Total bioassessment scores, expressed as percent of maximum, for three sites on Big Spring Creek. March 1999. The two additional bars for the Tresch site represent results from the analysis of replicates.

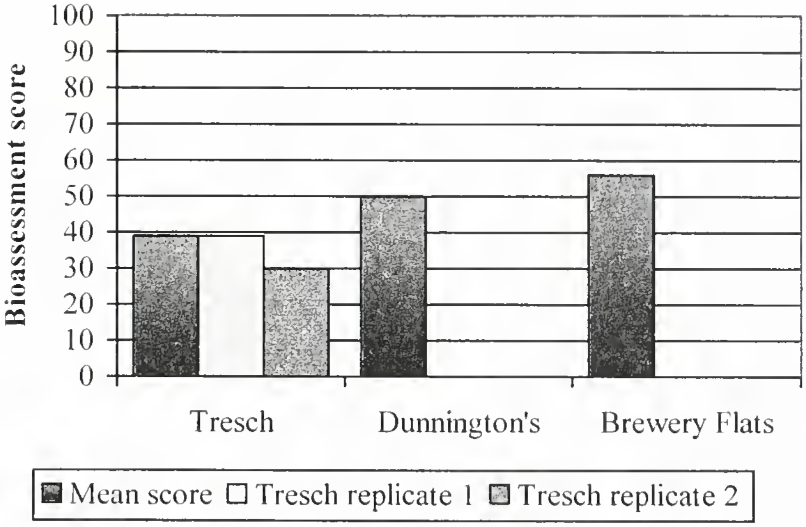

Table 5. Metric values and bioassessments for Big Spring Creek. March 1999. Metric values for Tresch represent averaged values from replicates. Results from individual replicates may be found in the Appendix.

	SITES				
	Tresch – rep. 1	Tresch – rep. 2	Tresch-mean values	Dunnington's	Brewery Flats
METRICS	**METRIC VALUES**				
Ephemeroptera richness	2	2	2	3	3
Plecoptera richness	0	0	0	4	2
Trichoptera richness	3	4	3.5	5	6
Number of sensitive taxa	0	0	0	0	0
Percent filterers	1	6	3.5	10.2	1
Percent tolerant taxa	12	20	16	20	31
	METRIC SCORES				
Ephemeroptera richness	1	1	1	1	1
Plecoptera richness	0	0	0	3	2
Trichoptera richness	2	2	2	3	3
Number of sensitive taxa	0	0	0	0	0
Percent filterers	3	2	3	1	3
Percent tolerant taxa	1	1	1	1	1
TOTAL SCORE (max.=18)	7	6	7	9	10
PERCENT OF MAX.	**39**	**30**	**39**	**50**	**56**
Impairment classification*			**MOD**	**SLI**	**MOD**
USE SUPPORT †			**PART**	**PART**	**PART**

1. Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.

*Use support designations: See Table 3a.

Aquatic invertebrate communities

The biotic index value (3.39) calculated for the assemblage collected at Tresch was low enough to be within expected limits for a foothill stream. However, the low mayfly richness contradicts this evidence for good water quality; only 2 mayfly taxa were collected at the site. This combination of seemingly contradictory observations may indicate that chemical water quality was good, but that temperature was elevated. Other evidence of warm water at the site was the presence of several taxa that prefer those conditions, such as the caddisfly *Helicopsyche borealis*, and the isopod *Caecidotea* sp. Physid snails were also abundant here. Small-scale instream habitat disturbance is suggested by the dearth of both caddisfly taxa and "clinger" taxa, typically indicative of fine sediments obliterating hard benthic surfaces and preventing colonization. Taxa richness is not particularly impressive, and predators are uncommon at the site, suggesting that habitats are not readily available, perhaps due to monotonous substrate or scouring flow conditions. Reach-scale habitat disturbances or shortcomings appear to also affect the benthic assemblage; no stoneflies were collected at the site. Such large-scale inadequacies might include loss of riparian function, channel alteration, or extensive streambank instability. Functionally, the benthic assemblage appears to be skewed toward collectors.

At Dunnington's, warm water temperatures were again suggested by the biotic index value (2.69) along with the low number of mayfly taxa (3) collected. Disturbance to large-scale habitat features may have been less pronounced at this site than at the others; evidence for this can be discerned in the 4 stonefly taxa collected here. They include the perlids *Claassenia sabulosa* and *Calineuria californica*, two of the 6 predatory taxa present at the site. This is a relatively high predator richness, and suggests that instream habitats were diverse and plentiful. Hard substrates appear to be free from substantial fine sediment deposition, since 11 "clinger" taxa and 5 caddisfly genera were present at the site. All expected functional components of a healthy assemblage are represented at Dunnington's.

At Brewery Flats, similar evidence concerning water quality could be discerned. The low biotic index value and the poor showing of mayfly taxa suggest elevated water temperatures. Physid snails were the dominant taxon present at the site, comprising 24% of sampled organisms, and giving strength to the hypothesis of warm water temperatures. Instream habitats appear to be compromised to a lesser degree than at Tresch; six caddisfly taxa were collected here as well as 8 "clinger" taxa. While these observations do not preclude fine sediment deposition and compromise of hard substrate surfaces, there does appear to be less effect from these insults at Brewery Flats. Disturbance to reach-scale habitat features may be reflected in the low number of stonefly taxa present in the sample. Only 2 were collected here. Functionally, the assemblage appears to be well-balanced, with all expected feeding groups represented.

CONCLUSIONS

- Evidence for damaging effects on benthic assemblages by the oil spill on Casino Creek seems to be largely lacking in these data. In similar studies, this writer has noted that oil spills may not have much impact on taxonomic composition of aquatic invertebrates, possibly because the oil floats, and its effects are confined to organisms which utilize the water surface. Notably, no air-breathing organisms were collected at any site, but it is not clear whether such creatures were present prior to the polluting event.

- Replicate samples collected at the Tresch site had very similar taxonomic compostions, and bioassessment metrics performed comparably between them.
- Warm water conditions appear to prevail at all sites visited.
- Fine sediment deposition and inadequate reach-scale habitat components limit biotic health at Tresch.
- At Brewery Flats and Dunnington's, habitat disturbances appear to have less of an effect on benthic assemblages than at Tresch.

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APPENDIX

Taxonomic data and summaries

Big Springs Creek

March 1999

Aquatic Invertebrate Taxonomic Data

Site Name: Big Spring Creek
Site ID: Tresch 1 3/8/99

Approx. percent of sample used: 17

Taxon	**Quantity**	**Percent**	**HBI**	**FFG**
Dugesia sp.	16	5.23	4	CG
Nais sp.	20	6.54	8	CG
Imma. Tubificid with cap. setae	11	3.59	9	CG
Sphaeriidae	1	0.33	8	CG
Physidae	7	2.29	8	CG
Acari	10	3.27	5	PA
Total Misc. Taxa	**65**	**21.24**		
Baetis tricaudatus	18	5.88	6	CG
Ephemerella inermis	145	47.39	1	CG
Total Ephemeroptera	**163**	**53.27**		
Brachycentrus americanus	2	0.65	1	OM
Hydropsyche sp.	4	1.31	4	CF
Lepidostoma sp.-sand case larvae	20	6.54	1	SH
Total Trichoptera	**26**	**8.50**		
Optioservus sp.	4	1.31	4	SC
Total Coleoptera	**4**	**1.31**		
~~*Diamesa* sp.~~	~~4~~	~~1.31~~	~~5~~	~~CG~~
Eukiefferiella Devonica Gr.	17	5.56	4	OM
Eukiefferiella Gracei Gr.	1	0.33	4	OM
Eukiefferiella Pseudomontana Gr.	8	2.61	8	OM
Microtendipes sp.	1	0.33	6	CG
Orthocladius sp.	10	3.27	6	CG
Pagastia sp.	5	1.63	1	CG
Parametriocnemus sp.	2	0.65	5	CG
Total Chironomidae	**48**	**15.69**		
Grand Total	**306**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: Big Spring Creek **Site ID: Tresch 1 3/8/99**

TOTAL ABUNDANCE	306
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	189
TOTAL NUMBER OF TAXA	20
Number EPT taxa	5

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	6	65	21.24
Odonata	0	0	0.00
Ephemeroptera	2	163	53.27
Plecoptera	0	0	0.00
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	3	26	8.50
Lepidoptera	0	0	0.00
Coleoptera	1	4	1.31
Diptera	0	0	0.00
Chironomidae	8	48	15.69

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	3.94

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	0	0	0.00
Parasite	1	10	3.27
Collector-gatherer	12	240	78.43
Collector-filterer	1	4	1.31
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	1	4	1.31
Shredder	1	20	6.54
Xylophage	0	0	0.00
Omnivore	4	28	9.15
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	1.00
Scraper/(Scraper + C.filterer)	0.50
Shredder/Total organisms	0.02

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Ephemerella inermis	145	47.39
Nais sp.	20	6.54
Lepidostoma sp.-sand case larv	20	6.54
Baetis tricaudatus	18	5.88
Eukiefferiella Devonica Gr.	17	5.56
SUBTOTAL 5 DOMINANTS	220	71.90
Dugesia sp.	16	5.23
Imma. Tubificid with cap. setae	11	3.59
Acari	10	3.27
Orthocladius sp.	10	3.27
Eukiefferiella Pseudomontana	8	2.61
TOTAL DOMINANTS	275	89.86

SAPROBIC INDICES

Hilsenhoff Biotic Index	3.21

DIVERSITY MEASURES

Shannon H (loge)	2.08
Shannon H (log2)	3.00
Evenness	0.69
Simpson D	0.25

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	77	25.00
Univoltine	223	72.88
Semivoltine	7	2.12

	#TAXA	ABUNDANCE	PERCENT
Tolerant	4	37	12.09
Intolerant	0	0	0.00
Clinger	4	155	50.65

Aquatic Invertebrate Taxonomic Data

Site Name: Big Spring Creek
Site ID: Tresch 1B 3/9/99

Approx. percent of sample used: 10

Taxon	**Quantity**	**Percent**	**HBI**	**FFG**
Dugesia sp.	7	2.33	4	CG
Nematoda	1	0.33	5	PA
Fossaria sp.	1	0.33	6	CG
Physidae	40	13.33	8	CG
Caecidotea sp.	1	0.33	8	CG
Acari	6	2.00	5	PA
Total Misc. Taxa	**56**	**18.67**		
Baetis tricaudatus	5	1.67	6	CG
Ephemerella inermis	93	31.00	1	CG
Total Ephemeroptera	**98**	**32.67**		
Brachycentrus americanus	1	0.33	1	OM
Helicopsyche borealis	11	3.67	7	SC
Hydropsyche sp.	17	5.67	4	CF
Lepidostoma sp.-sand case larvae	20	6.67	1	SH
Total Trichoptera	**49**	**16.33**		
Optioservus sp.	2	0.67	4	SC
Total Coleoptera	**2**	**0.67**		
Chelifera sp.	2	0.67	6	PR
Simulium sp.	1	0.33	6	CF
Antocha sp.	3	1.00	3	CG
Total Diptera	**6**	**2.00**		
~~*Diamesa* sp.~~	~~7~~	~~2.33~~	~~5~~	~~CG~~
Eukiefferiella Devonica Gr.	27	9.00	4	OM
Orthocladius sp.	27	9.00	6	CG
Pagastia sp.	24	8.00	1	CG
Parametriocnemus sp.	4	1.33	5	CG
Total Chironomidae	**89**	**29.67**		
Grand Total	**300**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: Big Spring Creek **Site ID: Tresch 1B 3/9/99**

TOTAL ABUNDANCE	300
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	147

TOTAL NUMBER OF TAXA	21
Number EPT taxa	6

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	6	56	18.67
Odonata	0	0	0.00
Ephemeroptera	2	98	32.67
Plecoptera	0	0	0.00
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	4	49	16.33
Lepidoptera	0	0	0.00
Coleoptera	1	2	0.67
Diptera	3	6	2.00
Chironomidae	5	89	29.67

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	1.65

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	1	2	0.67
Parasite	2	7	2.33
Collector-gatherer	11	212	70.67
Collector-filterer	2	18	6.00
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	2	13	4.33
Shredder	1	20	6.67
Xylophage	0	0	0.00
Omnivore	2	28	9.33
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.72
Scraper/(Scraper + C.filterer)	0.42
Shredder/Total organisms	0.02

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Ephemerella inermis	93	31.00
Physidae	40	13.33
Eukiefferiella Devonica Gr.	27	9.00
Orthocladius sp.	27	9.00
Pagastia sp.	24	8.00
SUBTOTAL 5 DOMINANTS	211	70.33
Lepidostoma sp.-sand case larv	20	6.67
Hydropsyche sp	17	5.67
Helicopsyche borealis	11	3.67
Dugesia sp.	7	2.33
Diamesa sp.	7	2.33
TOTAL DOMINANTS	273	91.00

SAPROBIC INDICES

Hilsenhoff Biotic Index	3.57

DIVERSITY MEASURES

Shannon H (loge)	2.32
Shannon H (log2)	3.35
Evenness	0.76
Simpson D	0.14

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	89	29.58
Univoltine	208	69.42
Semivoltine	3	1.00

	#TAXA	ABUNDANCE	PERCENT
Tolerant	5	59	19.67
Intolerant	0	0	0.00
Clinger	7	128	42.67

Aquatic Invertebrate Taxonomic Data

Site Name: Big Spring Creek

Site ID: Dunnington's 3/9/99

Approx. percent of sample used: 50

Taxon	Quantity	Percent	HBI	FFG
Dugesia sp.	2	0.66	4	CG
Lumbriculidae	6	1.98	8	CG
Physidae	3	0.99	8	CG
Total Misc. Taxa	**11**	**3.63**		
Baetis tricaudatus	33	10.89	6	CG
Ephemerella inermis	29	9.57	1	CG
Rhithrogena sp.	2	0.66	0	SC
Total Ephemeroptera	**64**	**21.12**		
Calineuria californica	1	0.33	2	PR
Claassenia sabulosa	1	0.33	3	PR
Isogenoides sp.	5	1.65	2	PR
Isoperla sp.	8	2.64	2	PR
Total Plecoptera	**15**	**4.95**		
Brachycentrus americanus	34	11.22	1	OM
Glossosoma sp.	59	19.47	1	SC
Hydropsyche sp.	31	10.23	4	CF
Lepidostoma sp.-sand case larvae	12	3.96	1	SH
Rhyacophila Brunnea Gr.	8	2.64	1	PR
Total Trichoptera	**144**	**47.52**		
Cleptelmis sp.	1	0.33	4	CG
Lara avara	1	0.33	4	SH
Optioservus sp.	24	7.92	4	SC
Total Coleoptera	**26**	**8.58**		
Chelifera sp.	1	0.33	6	PR
Antocha sp.	29	9.57	3	CG
Total Diptera	**30**	**9.90**		
Eukiefferiella Brehmi Gr.	1	0.33	4	OM
Eukiefferiella Devonica Gr.	6	1.98	4	OM
Orthocladius sp.	1	0.33	6	CG
Pagastia sp.	4	1.32	1	CG
Tvetenia sp.	1	0.33	5	CG
Total Chironomidae	**13**	**4.29**		
Grand Total	**303**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: Big Spring Creek Site ID: Dunnington's 3/9/99

TOTAL ABUNDANCE	303
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	223
TOTAL NUMBER OF TAXA	25
Number EPT taxa	12

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	3	11	3.63
Odonata	0	0	0.00
Ephemeroptera	3	64	21.12
Plecoptera	4	15	4.95
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	5	144	47.52
Lepidoptera	0	0	0.00
Coleoptera	3	26	8.58
Diptera	2	30	9.90
Chironomidae	5	13	4.29

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	17.15

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	6	24	7.92
Parasite	0	0	0.00
Collector-gatherer	10	109	35.97
Collector-filterer	1	31	10.23
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	3	85	28.05
Shredder	2	13	4.29
Xylophage	0	0	0.00
Omnivore	3	41	13.53
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	2.74
Scraper/(Scraper + C.filterer)	0.73
Shredder/Total organisms	0.01

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Glossosoma sp.	59	19.47
Brachycentrus americanus	34	11.22
Baetis tricaudatus	33	10.89
Hydropsyche sp.	31	10.23
Ephemerella inermis	29	9.57
SUBTOTAL 5 DOMINANTS	186	61.39
Antocha sp.	29	9.57
Optioservus sp.	24	7.92
Lepidostoma sp.-sand case larv.	12	3.96
Isoperla sp.	8	2.64
Rhyacophila Brunnea Gp.	8	2.64
TOTAL DOMINANTS	267	88.12

SAPROBIC INDICES

Hilsenhoff Biotic Index	2.69

DIVERSITY MEASURES

Shannon H (loge)	2.19
Shannon H (log2)	3.16
Evenness	0.68
Simpson D	0.09

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	44	14.60
Univoltine	193	63.61
Semivoltine	66	21.78

	#TAXA	ABUNDANCE	PERCENT
Tolerant	4	61	20.13
Intolerant	0	0	0.00
Clinger	11	219	72.28

Aquatic Invertebrate Taxonomic Data

Site Name: Big Spring Creek

Site ID: Brewery Flats 3/8/99

Approx. percent of sample used: 13

Taxon	Quantity	Percent	HBI	FFG
Dugesia sp.	11	3.19	4	CG
Limnodrilus hoffmeisteri	10	2.90	9	CG
Sphaeriidae	5	1.45	8	CG
Physidae	82	23.77	8	CG
Total Misc. Taxa	**108**	**31.30**		
Baetis tricoudatus	10	2.90	6	CG
Ephemerella inermis	56	16.23	1	CG
Tricorythodes minutus	1	0.29	4	CG
Total Ephemeroptera	**67**	**19.42**		
Isogenoides sp.	2	0.58	2	PR
Isoperla sp.	3	0.87	2	PR
Total Plecoptera	**5**	**1.45**		
Brachycentrus americanus	8	2.32	1	OM
Glossosoma sp.	37	10.72	1	SC
Helicopsyche borealis	1	0.29	7	SC
Hydropsyche sp.	4	1.16	4	CF
Lepidostomo sp.-sand case larvae	52	15.07	1	SH
Rhyacophila Brunnea Gr.	4	1.16	1	PR
Total Trichoptera	**106**	**30.72**		
Optioservus sp.	12	3.48	4	SC
Total Coleoptera	**12**	**3.48**		
Chelifera sp.	1	0.29	6	PR
Antocha sp.	13	3.77	3	CG
Total Diptera	**14**	**4.06**		
Eukiefferiella Devonica Gr.	4	1.16	4	OM
Micropsectra sp.	1	0.29	7	CG
Odontomesa sp.	1	0.29	4	CG
Orthocladius sp.	14	4.06	6	CG
Pogastia sp.	10	2.90	1	CG
Parametriocnemus sp.	1	0.29	5	CG
Phaenopsectra sp.	1	0.29	7	SC
Tvetenia sp.	1	0.29	5	CG
Total Chironomidae	**33**	**9.57**		
Grand Total	**345**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: Big Spring Creek **Site ID: Brewery Flats** **3/8/99**

TOTAL ABUNDANCE	345
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	178
TOTAL NUMBER OF TAXA	26
Number EPT taxa	11

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	4	108	31.30
Odonata	0	0	0.00
Ephemeroptera	3	67	19.42
Plecoptera	2	5	1.45
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	6	106	30.72
Lepidoptera	0	0	0.00
Coleoptera	1	12	3.48
Diptera	2	14	4.06
Chironomidae	8	33	9.57

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	5.39

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	4	10	2.90
Parasite	0	0	0.00
Collector-gatherer	14	216	62.61
Collector-filterer	1	4	1.16
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	4	51	14.78
Shredder	1	52	15.07
Xylophage	0	0	0.00
Omnivore	2	12	3.48
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	12.75
Scraper/(Scraper + C.filterer)	0.93
Shredder/Total organisms	0.04

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Physidae	82	23.77
Ephemerella inermis	56	16.23
Lepidostoma sp.-sand case larv.	52	15.07
Glossosoma sp.	37	10.72
Orthocladius sp.	14	4.06
SUBTOTAL 5 DOMINANTS	241	69.86
Antocha sp.	13	3.77
Optioservus sp.	12	3.48
Dugesia sp.	11	3.19
Limnodrilus hoffmeisteri	10	2.90
Baetis tricaudatus	10	2.9
TOTAL DOMINANTS	297	86.09

SAPROBIC INDICES

Hilsenhoff Biotic Index	3.81

DIVERSITY MEASURES

Shannon H (loge)	2.10
Shannon H (log2)	3.03
Evenness	0.64
Simpson D	0.11

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	44	12.83
Univoltine	276	80.07
Semivoltine	25	7.10

	#TAXA	ABUNDANCE	PERCENT
Tolerant	5	106	30.72
Intolerant	0	0	0.00
Clinger	8	135	39.13

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INTRODUCTION

Benthic assemblages are aptly applied to aquatic bioassessment since they are known to be key indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations. Multimetic approaches to bioassessment use attributes of the assemblage in an integrated way to measure overall biotic condition.

The additive multimetric approach designed by Plafkin et al.(1989) and adapted for use in the State of Montana has been defined as "...an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995) Community attributes which can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into an overall score reduces variance and increases precision of the assessment. (Fore et al. 1995).

METHODS

Benthic macroinvertebrate sampling was performed by personnel of Water Consulting, Inc. of Hamilton, Montana in mid August and early September. The traveling kick-net method described by Bukantis (1997) was utilized. Single samples were collected from riffled reaches in ten streams, five streams draining east side watersheds and five draining west side watersheds. The resulting ten samples were from the following sites:

East side sites (north to south):
- Three Mile Creek: downstream of culverted road crossing (Rathburn Lane)
- North Burnt Fork Creek: upstream of bridge crossing at Wildfowl Lane
- Skalkaho Creek: downstream from Hwy. 93 bridge
- Rye Creek: upstream of Hwy. 93 bridge
- East Fork Bitterroot River: upstream of Conner cutoff bridge

West side sites (north to south):
- Kootenai Creek: downstream of Hwy. 93 bridge
- Fred Burr Creek: immediately above Meridian Rd. West bridge
- Sweathouse Creek: immediately above Meridian Rd. bridge
- Lost Horse Creek: immediately below Hwy. 93 bridge
- West Fork Bitterroot River: at Conner cutoff bridge (upstream)

In addition, habitat quality was visually evaluated at each site and reported by means of the habitat assessment protocol recommended by Bukantis (1997).

Sample processing and data analysis was contracted to Rhithron Biological Associates. In the laboratory, the Rapid Bioassessment Protocol III (RBP III) sorting method was used to obtain subsamples of 300 (+/- 10%) organisms from each sample. Community structure, function and sensitivity to impact were characterized for each subsample using two methods prescribed by the

Montana Department of Environmental Quality (Montana DEQ). First, data is evaluated using the Montana Valleys and Foothill Prairies ecoregion reference. In this approach, benthic communities were compared to reference criteria established by Montana DEQ for streams of the entire Montana Valleys and Foothill Prairies ecoregion, which is geographically large and disjunct, and varied in geology, soils and vegetation. In the second approach, internal references for streams of the east side and those of the west side were assembled, and data is compared to the appropriate internal reference. The internal reference approach implies that reference values for each metric were established based on the performance of that metric in the communities of the Bitterroot Valley streams alone. Separate reference criteria were assembled for east and west side streams since the varying geology of their source watersheds produced subtle differences in certain functional attributes of the communities. East side streams head in sedimentary rocks of the Belt series, while west side streams originate on the granitic Idaho batholith.

Total, integrated metric scores were obtained for each method by summing scores for all metrics, and an impairment classification and "use support" designation were derived from this total score.

RESULTS

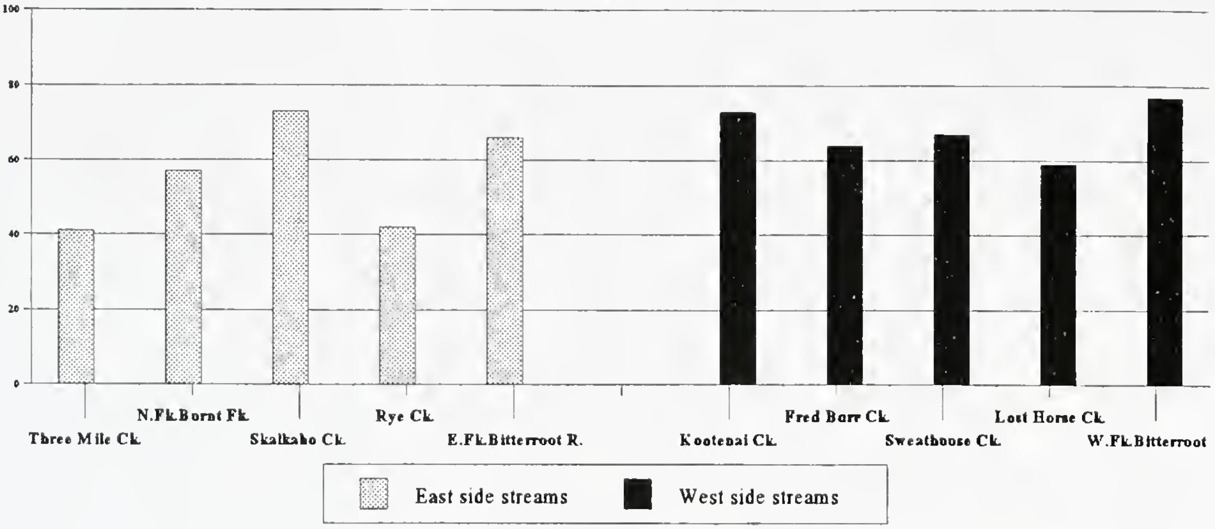
Habitat assessment

Figure 1 compares habitat assessment results for all sites studied. Breakdown of total scores into the nine evaluated components is presented in Tables 1 and 2. Scores for east side streams were generally lower than those for west side streams: mean habitat score for the five east side streams was 55.8, while mean score for streams of the west side was 68. West side streams generally were perceived to have less sediment deposition, better bank vegetative cover, and wider riparian zones than east side streams, though there were some exceptions to this.

Marginal habitat conditions were noted at the sites on Three Mile Creek, Rye Creek, and Lost Horse Creek. The site on Three Mile Creek was perceived to have severe sediment (silt and sand) deposition, with associated bank instability and poor bank vegetative cover. Though bank stability was somewhat better at Rye Creek, sediment deposition was a problem here, too. Riparian vegetation was non-existent at the Rye Creek site. Overwidening, though not evaluated in this habitat assessment, was also reported. Three Mile Creek and Rye Creek received the two lowest habitat assessment scores of all sites studied. Bank instability and marginal to poor vegetative cover was evident at the Lost Horse Creek site but sediment deposition or other instream impairment was not perceived to be severe here. Riparian width received an optimal score, but dewatering resulted in a marginal channel flow status.

All other Bitterroot Valley stream sites were perceived to have sub-optimal habitat quality. Best habitat quality was evident at the site on the West Fork of the Bitterroot River, while sites on Kootenai Creek and Skalkaho Creek had moderately high scores. Bank vegetation was perceived to be marginal at the site on the West Fork, and sub-optimal to marginal bank stability was noted. All other habitat parameters were rated optimal at this site. No remarkable habitat impairments

Figure 1. Total habitat assessment scores: Bitterroot Valley streams, 1997.



were perceived at the Kootenai Creek site. Moderate bank instability and some disruption of bank vegetative cover was noted there. Skalkaho Creek had poor bank vegetative coverage and marginal riparian width along one bank, but even there, young cottonwoods were noted.

Various habitat impairments were reported at the other sites, including marginal flow status at the site on the North Fork of Burnt Fork. Marginal bank stability, marginal to poor vegetative cover and riparian width were also noted here. Sediment deposition was moderate at the site on Sweathouse Creek, riparian width was poor on one bank of the site at Fred Burr Creek, and the East Fork of the Bitterroot River was perceived to have one-sided bank stability and vegetative cover problems.

Bioassessments

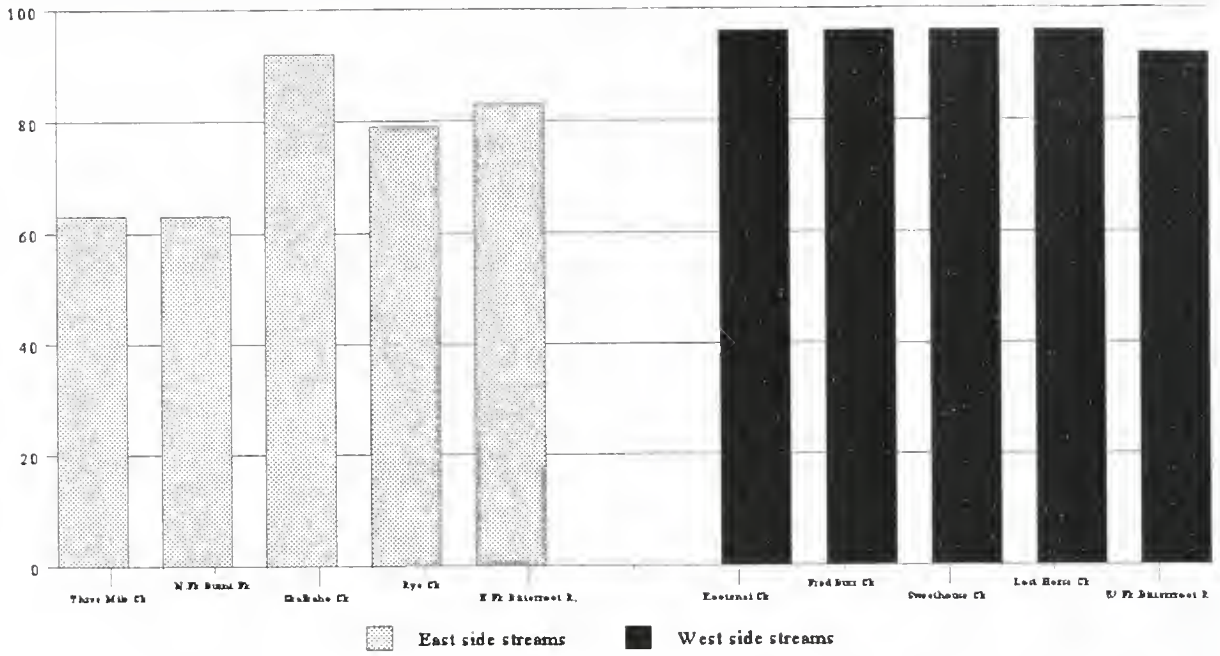
Macroinvertebrate taxa lists, metric results and other information for each sample are given in the Appendix.

The Montana Valleys and Foothill Prairies ecoregional reference

Figure 2 compares total bioassessment scores from integrated and summed metrics using the ecoregional reference scoring criteria. Table 1 summarizes this method and criteria. Breakdown of scores for each metric is presented in Tables 5 and 6.

Comparing Bitterroot streams to streams of the entire ecoregion accentuates the differences between east side streams and west side streams. Average bioassessment score for east side streams was 76% of maximum. Streams of the west side generally scored much higher; the average bioassessment score was 95. All west side streams were classified as non-impaired using the ecoregional reference criteria. Figure 2 illustrates that the ecoregional reference method scores four of the streams identically, with only the West Fork of the Bitterroot River appearing somewhat distinguished from the rest. Of the five east side streams studied, Skalkaho Creek and the East Fork of the Bitterroot River were classified as non-impaired. Three Mile Creek, the North Fork of Burnt Fork and Rye Creek all were slightly impaired. Streams of the east side are

Figure 2. Total bioassessment scores, Montana Valleys and Foothill Prairies ecoregion reference. Streams of the Bitterroot Valley, August-September 1997.



more distinguished from each other than those of the west side when this larger scale comparison method is used.

Internal references

Separate internal references were constructed for east side and west side streams, since the variation in geology and aspect suggested that this would be necessary. Tables 3 and 4 summarize this method and its criteria. Tables 5 and 6 breakdown the scores for individual metrics for each stream site.

When compared only with each other by means of the internal reference criteria, the streams of the east side maintain their relative quality with respect to one another. Skalkaho Creek provided reference values for all metrics used in the evaluation, and thus obtained the maximal score as a percentage of the reference condition. Three Mile Creek and the North Fork of Burnt Fork were classified as slightly impaired under this scheme, and Rye Creek and the East Fork of the Bitterroot River scored in the non-impaired range, though with lower scores than Skalkaho Creek.

The internal reference method was able to reveal distinctions among the west side streams more clearly than the ecoregional reference did. When compared only to each other, streams of the west side were all classified as slightly impaired except for Kootenai Creek, which scored in the non-impaired range. No single site provided all metric reference values, as was the case with the east side streams.

Figure 3. Total bioassessment scores for streams of the east side of the Bitterroot Valley, using an east side internal reference.

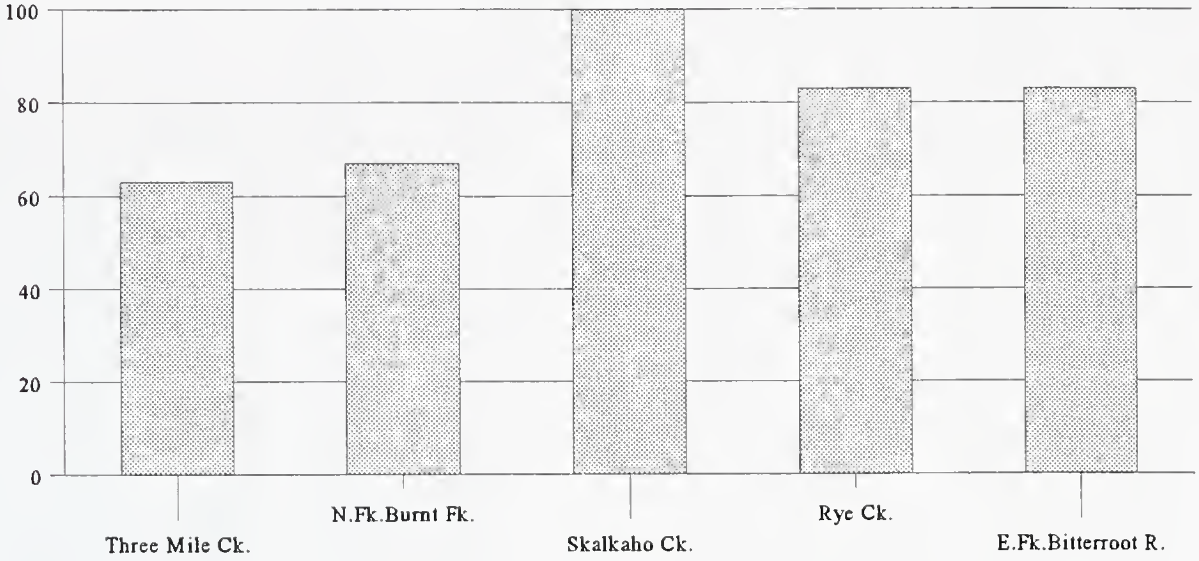
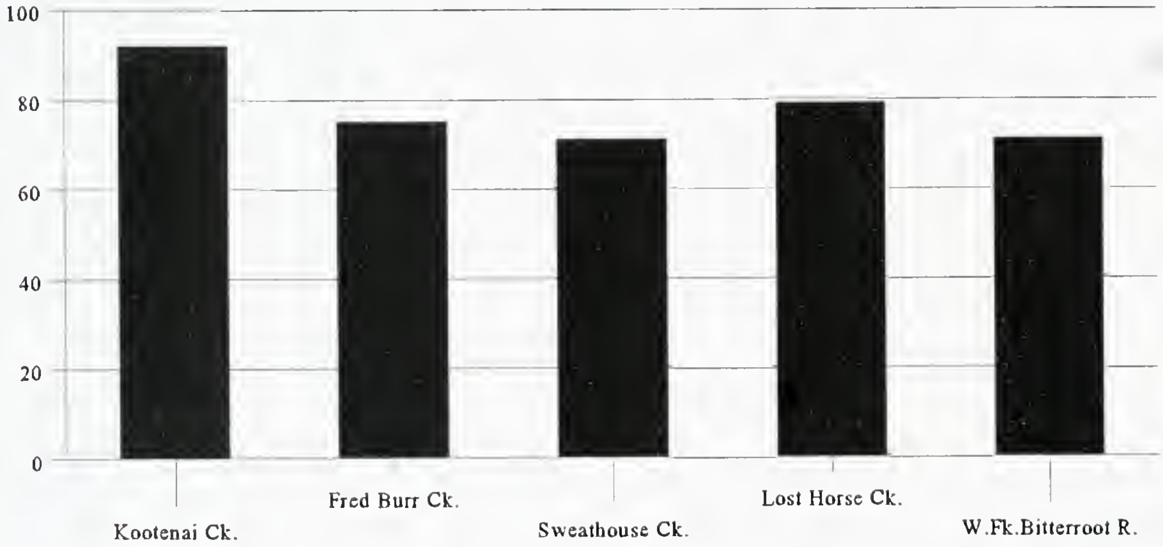


Figure 4. Total bioassessment scores for streams of the west side of the Bitterroot Valley, using a west side internal reference.



Macroinvertebrate communities

The highest biotic index value (4.34), and the lowest bioassessment score of any site studied were recorded at Three Mile Creek. High values of the biotic index may indicate organic and/or nutrient pollution, high water temperatures or sediment-degraded habitat. While not extremely high, the biotic index value calculated here suggests that some or all of these factors may contribute to the impairment of biotic health of Three Mile Creek. The site also recorded the highest proportion of the gatherer functional group (74%) including an abundance of the ubiquitous and moderately tolerant mayfly *Baetis tricaudatus*, the dominant taxon here. The high proportion of gatherers suggests that fine particulate organic matter is plentiful at the site, and that the benthic habitat lacks complexity, perhaps because of dominance of monotonous substrate particles. This interpretation appears to be supported by the habitat evaluator's comment that recent sand and silt deposition was apparent at the study site. Sediment-tolerant taxa that were plentiful at the site included the midges in the Cricotopus Trifascia Gp. and the mayfly *Tricorythodes minutus*. A moderately high metals tolerance was noted for this assemblage (metals tolerance index = 4.17), suggesting that a mild toxic input may be present here. However, the metals tolerance index used here is correlated with biotic index score, and so this elevated value may only reflect the impacts tracked by that index.

The dominant taxon in the North Fork Burnt Fork assemblage was the moderately tolerant midge *Micropsectra* sp. which made up 48% of the sample. Lower biotic index score was a favorable sign for water quality at this site, as was the presence of the decapod *Pacifastacus* sp. The high proportion of shredders (20%) recorded in the data may be erroneous, since a single taxon, *Lepidostoma* sp. contributes most of this total. This caddisfly is designated as a shredder in the Montana benthic taxa list, but its actual feeding strategy is not well known, and some experts consider it to function as a gatherer (Wisseman, personal communication). Abundant shredders in an assemblage generally suggests that allocthonous inputs of woody debris are available both as food and as habitat elements, but the habitat evaluator at the North Fork Burnt Fork site observed a severely impaired riparian zone. The degraded riparian zone is also evident in the benthic community with its low percent of mayfly, stonefly and caddisfly abundance (EPT % was 41%, but two caddisfly taxa, the tolerant *Hydropsyche* sp. and *Lepidostoma* sp., comprised 28% of the sampled community.)

Skalkaho Creek rated the highest habitat score as well as the highest bioassessment score of the east side streams. High taxa richness (34) suggests diverse instream habitat and good water quality, which is also indicated by the low biotic index score (3.03). High EPT percent (61%) suggests that riparian health is adequate, and that the reach-scale geomorphic structure of this stream site is essentially intact. Moderate abundances of especially sensitive taxa found at the Skalkaho Creek site include the mayflies *Drunella doddsi* and *Drunella grandis* and a caddisfly of the Rhyacophila Angelita Gp.

Rye Creek had the highest metals tolerance index score (4.31) of any site studied, a moderate elevation. This suggests that a mild toxic input may add to the impairment of biotic health at this site. However, the elevated score may be spurious, because of the correlation of metals index and biotic index scores noted above. The moderately elevated biotic index score (4.08) suggests impact due to organic and/or nutrient pollution, elevated water temperature or sediment inputs. Some or all of these factors may contribute to the impairment of biotic health at the Rye Creek site. Only 33% of the sampled assemblage was comprised of mayflies, stoneflies and caddisflies, suggesting that riparian function and/or reach-scale structure are impaired. Twenty-five percent of the sampled assemblage, the highest proportion among the east side sites, was comprised of especially tolerant taxa, including a tubificid worm, and the sediment-tolerant elmid beetle *Optioservus* sp. These interpretations are substantiated by the observations of the habitat evaluator, who noted absence of riparian vegetation, and "huge bank erosion problems" near the sampled reach.

Excellent taxa richness and EPT richness characterized the bioassessment score of the site on the East Fork of the Bitterroot River. These findings suggest good diversity of instream habitat and excellent water quality. Seven stonefly taxa were collected here, including the sensitive perlid *Doroneuria* sp. and the sediment-intolerant chloroperlid *Plumiperla* sp. High plecoptera taxa richness is associated with diverse benthic habitat, good reach-scale stream structure, functioning riparian zone and streambank stability. While the habitat evaluator noted erosion of streambanks and point bar formation due to sediment deposition, the benthic community does not yet indicate impairment due to these impacts. However, the habitat assessment certainly indicates the vulnerablility of the biotic health here.

As mentioned earlier, the stream sites on the west side of the Bitterroot Valley tended to score higher on habitat assessment parameters (Figure 1) as well as on bioassessment variables (Figure 2.) The Kootenai Creek site is a good example of this pattern. The biotic index calculated for the sampled benthic assemblage was 1.51, the lowest index score of any site studied. This low score suggests that water quality in Kootenai Creek is excellent, with no appreciable effect of organic or nutrient pollution, elevated water temperature or sedimentation on biotic health. Dominant taxon here (36% of the sampled community) was the sensitive mayfly *Rhithrogena* sp.; nine percent of the assemblage was comprised of the suberbly intolerant *Drunella doddsi*.

The bioassessment score for the site on Fred Burr Creek, however, indicated that there was some mild impairment of biotic health. Thirty-one percent of the sampled assemblage was comprised of tolerant taxa, including the sediment-tolerant elmid beetle *Optioservus* sp. However, no instream sediment deposition was noted in the habitat assessment, although evidence of streambank instability and erosion within the reach was observed. Elmid beetles are gregarious in habit, and samples collected with kick-nets can often be overwhelmed by gregarious taxa. Perhaps the abundance of *Optioservus* sp. is a spurious finding. Seven caddisfly taxa, including the pollution-sensitive philopotamid *Wormaldia* sp. were collected here, suggesting diverse instream habitat. Excellent EPT richness also indicates good small-scale habitat quality, and suggests good reach-scale stream structure as well.

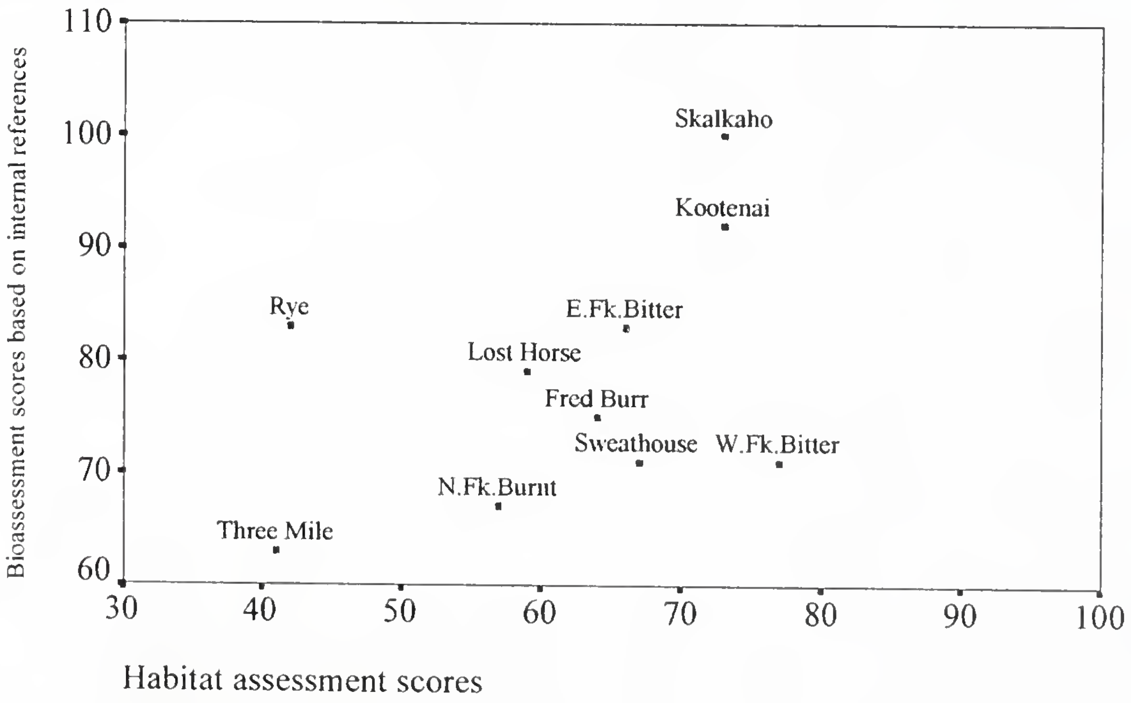
Moderate sediment deposition was noted in the habitat assessment of the site on Sweathouse Creek, and the impact is evident by the dominance of two sediment-tolerant elmids, *Optioservus* sp. and *Zaitzevia* sp. Together, these two taxa comprise forty-seven percent of the assemblage sampled at this site. Mayflies, stoneflies and caddisflies together made up only 37% of the creatures collected here, suggesting that instream habitat and/or reach-scale structure were compromised. Water quality appears to be unaffected by nutrient or organic pollutants, since the biotic index score was low (3.50) and ephemeroptera taxa richness was high. In fact, Sweathouse Creek had more mayfly taxa (10) than any of the streams studied, and these taxa included the pollution-sensitive heptageniids *Drunella doddsi* and *Rhithrogena* sp.

The dominant taxon of the benthic assemblage at the site on Lost Horse Creek was the sensitive mayfly *Rhithrogena* sp., which made up nineteen percent of the animals in the sample. Lost Horse Creek also recorded the highest taxa richness (39) of all sites studied. This finding, as well as the high EPT taxa richness (20) suggests that biotic health here is not substantially impaired by reach-scale impacts such as channelization with loss of natural meanders and pool/riffle relationships or excessive overwidening. The perception of excellent riparian zone width is reflected in this metric score as well. The low biotic index score (3.24) indicates that water quality is unimpaired. In spite of observed streambank instability, sediment deposition was reported to be minimal, and sediment-tolerant taxa occur in insignificant numbers.

Excellent water quality at the West Fork of the Bitterroot River site was indicated by the low biotic index score (2.92). However, some habitat impairment is evident in the moderately low taxa richness (25) and EPT richness (16), and in the low density of organisms at the sampled site. Only 201 organisms were collected in the entire sample, even though substrate was kicked for six minutes. The habitat assessment does not reveal what the source of impact might be, since marginal streambank instability and vegetative cover were the only impairments to habitat quality noted. Neither sediment deposition nor embeddedness was associated with the streambank findings at the site. Relatively high numbers of *Pteronarcys* sp. (12% of the sampled assemblage), a shredder, suggest that allochthonous riparian inputs of woody debris are substantial at this site, and the positive implications of an abundance of this stonefly for the fishery are well-known.

Figure 5 illustrates the relationship between habitat assessment scores and bioassessment scores (internal reference criteria) for these Bitterroot Valley streams. Most sites show the typical relationship of scores when water quality is essentially unimpaired: biotic assessment scores show positive correlation with habitat scores. The position of the Rye Creek scores illustrates the condition expected when organic and/or nutrient pollution compromises water quality; a higher than expected bioassessment score accompanies a low habitat assessment score.

Figure 5. Bioassessment score based on internal reference criteria plotted against habitat score. Streams of the Bitterroot Valley, August-September 1997.



CONCLUSIONS

- Subtle differences in ecological function between east and west side assemblages substantiated the necessity to formulate separate internal references for the two groups of sites. Geological differences in the mountains of either side of the valley were thought to be the source of functional differences in the benthic assemblages. Specifically, these differences were a greater average proportion of collector-gatherers in the east side communities (a mean value of 62 % for east side sites vs. 50% for west side sites), and a greater average proportion of scrapers in the west side communities (38% vs. 16%). These findings suggest that conditions favoring the growth of diatoms and other algal films is greater for west side streams than for east side streams, and that food webs in east side streams are based more on sediment spiced with organic material. The findings also suggest an excellent area for further research.
- Streams of the west side of the Bitterroot Valley averaged higher habitat assessment and bioassessment scores than the streams of the east side.
- Where biotic health of east side streams indicated impairment, impacts appeared to be in the form of sediment deposition combined with organic and/or nutrient pollution. This was the case for Three Mile Creek and Rye Creek.
- Where biotic health of west side streams indicated impairment, sediment deposition was suggested by the biotic community composition. This was the case for Sweathouse Creek. Evidence for sediment deposition at the site on Fred Burr Creek was not definitive.
- On the east side, the North Fork of Burnt Fork Creek, Skalkaho Creek and the East Fork of the Bitterroot River all yielded benthic assemblages which suggested that water and habitat quality remain unimpaired. Habitat assessments, however, suggested the vulnerability of these sites.
- On the west side, Kootenai Creek and Lost Horse Creek exhibited no water or habitat quality impairment to the health of the macroinvertebrate biota. The low density of animals in the benthos of the West Fork of the Bitterroot River as well as other biotic evidence suggests impairment to biotic health in that stream, though the source of the impairment is unclear.

TABLES

Table 1. Montana Valleys and Foothill Prairies ecoregion reference and scoring criteria. (From Bukantis 1998.)

	Score			
Metric	**3**	**2**	**1**	**0**
Taxa richness	>28	28-21	21-14	<14
EPT richness	>14	14-13	12-11	<11
Biotic Index	<4	4-5	5-6	>6
% Dominant taxon	<30	30-40	40-50	>50
% Collectors (gath + filter)	<60	60-75	75-90	>90
% Scrapers + shredders	>30	30-20	20-10	<10
% EPT	>60	60-45	45-30	<30
% Hydropsychinae of trichoptera	<75	75-85	85-95	>95

Table 2a. Criteria for the assignment of support classifications / standards violation thresholds (from Bukantis, 1997)

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table 2b. Criteria for the assignment of impairment classifications (from Plafkin et al. 1989).

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

Table 3. **Internal reference values and criteria for assigning scores to metrics based on percent comparability to reference values (adapted from McGuire 1995):**

metric	East Side streams of the Bitterroot Valley 1997	Scoring Criteria 3	2	1	0	*
Taxa richness	34	> 80%	80-60%	60-40%	< 40%	a
EPT richness	20	> 85%	85-70%	70-50%	< 50%	a
Biotic index	3.03	> 90%	90-80%	80-70%	< 70%	b
% dominant taxon	13	> 60%	60-45%	45-30%	< 30%	b
%Collector(g+ff)	66	> 90%	90-80%	80-70%	< 70%	b
% Scraper +Shredder	26	> 80%	80-60%	60-40%	< 40%	a
% EPT	61	> 75%	75-50%	50-25%	< 25%	a
% Hydropsych. of Trichop.	24	< 50%	50-70%	70-90%	> 90%	c

[1] 1996 Internal reference values are the "best" appropriate values among those calculated from 1997 data.

* a = score is ratio of study site to reference x 100.

* b = score is ratio of reference to study site x 100.

* c = score is based on the actual value, not a percentage of reference.

Table 4. **Internal reference values and criteria for assigning scores to metrics based on percent comparability to reference values (adapted from McGuire 1995):**

metric	West Side streams of the Bitterroot Valley 1997	Scoring Criteria				*
		3	2	1	0	
Taxa richness	39	> 80%	80-60%	60-40%	< 40%	a
EPT richness	22	> 85%	85-70%	70-50%	< 50%	a
Biotic index	2.92	> 90%	90-80%	80-70%	< 70%	b
% dominant taxon	19	> 60%	60-45%	45-30%	< 30%	b
%Collector(g+ff)	33	> 90%	90-80%	80-70%	< 70%	b
% Scraper +Shredder	52	> 80%	80-60%	60-40%	< 40%	a
% EPT	79	> 75%	75-50%	50-25%	< 25%	a
% Hydropsych. of Trichop.	0	< 50%	50-70%	70-90%	> 90%	c

[1] 1996 Internal reference values are the "best" appropriate values among those calculated from 1997 data.

* a = score is ratio of study site to reference x 100.

* b = score is ratio of reference to study site x 100.

* c = score is based on the actual value, not a percentage of reference.

Table 5. Stream and riparian habitat assessment: Streams of the East side, Bitterroot Valley, August-September, 1997.

Max possible score	Location:	Three Mile Creek	North Fork Burnt Fork	Skalkaho Creek	Rye Creek	East Fork Bitterroot River
	Parameter					
10	riffle development	3	4	6	3	10
10	substrate development	4	9	7	3	8
20	embeddedness	7	16	18	11	18
20	channel alteration	16	18	11	11	11
20	sediment deposition	5	15	17	6	11
20	flow status	16	10	18	11	16
10/10	bank stability (right/left)	2 / 2	5 / 4	10 / 7	8 / 6	8 / 4
10/10	bank vegetative cover (right/left)	1 / 1	3 / 2	1 / 8	6 / 2	5 / 2
10/10	riparian width (right/left)	4 / 4	2 / 3	3 / 10	0 / 0	6 / 6
160	TOTAL:	65	91	116	67	105
	PERCENT OF MAXIMUM:	41	57	73	42	66
	CONDITION[1]:	MARGINAL	SUB-OPTIMAL	SUB-OPTIMAL	MARGINAL	SUB-OPTIMAL

1. Condition categories: Optimal > 81% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%.

Table 6. Stream and riparian habitat assessment: Streams of the West side, Bitterroot Valley, August-September, 1997.

Max possible score	Location:	Kootenai Creek	Fred Burr Creek	Sweathouse Creek	Lost Horse Creek	West Fork Bitterroot River
	Parameter					
10	riffle development	4	2	4	5	9
10	substrate development	8	7	5	10	9
20	embeddedness	19	12	11	18	18
20	channel alteration	18	11	10	16	16
20	sediment deposition	13	20	10	11	18
20	flow status	13	19	18	6	16
10/10	bank stability (right/left)	7 / 5	8 / 4	9 / 9	1 / 1	7 / 5
10/10	bank vegetative cover (right/left)	7 / 4	7 / 4	8 / 8	2 / 4	4 / 3
10/10	riparian width (right/left)	8 / 10	2 / 7	7 / 8	10 / 10	9 / 9
160	TOTAL:	116	103	107	94	123
	PERCENT OF MAXIMUM:	73	64	67	59	77
	CONDITION[1]:	SUB-OPTIMAL	SUB-OPTIMAL	SUB-OPTIMAL	MARGINAL	SUB-OPTIMAL

[1] Condition categories: Optimal > 81% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%.

Table 7. Metric values, percentage of reference, and bioassessments for streams of the East side, Bitterroot Valley, August-September, 1997.

metric	Three Mile Creek		North Fork Burnt Fork		Skalkaho Creek		Rye Creek		East Fork Bitterroot River	
Taxa richness	33		26		34		32		34	
EPT richness	13		12		20		15		20	
Biotic index	4.34		3.57		3.03		4.08		3.51	
% dominant taxon	33		48		13		16		31	
% Collector (g+ff)	78		71		66		72		68	
% Scrapers + Shredders	16		24		26		24		20	
% EPT	55		41		61		33		50	
% Hydropsychinae of Trichoptera	75		32		24		43		38	
% of internal reference										
Taxa richness	97		76		100		94		100	
EPT richness	65		60		100		75		100	
Biotic index	70		85		100		74		86	
% dominant taxon	39		27		100		81		42	
% Collector (g+ff)	85		93		100		92		97	
% Scrapers + Shredders	62		92		100		92		77	
% EPT	90		67		100		54		82	
% Hydropsychinae of Trichoptera	n.a.		n.a.		n.a.		n.a.		n.a.	
metric score[1]	A	B	A	B	A	B	A	B	A	B
Taxa richness	3	3	2	2	3	3	3	3	3	3
EPT richness	2	1	1	1	3	3	3	2	3	3
Biotic index	2	1	3	2	3	3	2	1	3	2
% dominant taxon	2	1	1	0	3	3	3	3	2	1
% Collector (g+ff)	1	2	2	3	2	3	2	3	2	3
% Scrapers + Shredders	1	2	2	3	2	3	2	3	2	2
% EPT	2	3	1	2	3	3	1	2	2	3
% Hydropsychinae of Trichoptera	2	2	3	3	3	3	3	3	3	3
total score (max = 24)	15	15	15	16	22	24	19	20	20	20
% reference	63	63	63	67	92	100	79	83	83	83
classification *	SLI	SLI	SLI	SLI	NON	NON	SLI	NON	NON	NON
use support	PARTIAL		PARTIAL		FULL		FULL		FULL	

* classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired.

[1] Both the ecoregional reference and the internal reference methods are reported in this table. Column A shows the metric scores calculated on the basis of the Montana Valleys and Foothill Prairies ecoregion criteria. Column B shows the metric scores calculated on the basis of the internal reference for East side Bitterroot streams criteria as in Table 1.

Table 8. Metric values, percentage of reference, and bioassessments for streams of the West side, Bitterroot Valley, August-September, 1997.

metric	Kootenai Creek		Fred Burr Creek		Sweathouse Creek		Lost Horse Creek		West Fork Bitterroot River	
Taxa richness	29		32		35		39		25	
EPT richness	19		20		22		20		16	
Biotic index	1.55		3.35		3.50		3.24		2.92	
% dominant taxon	36		23		26		19		25	
% Collector (g+ff)	33		57		58		54		50	
% Scrapers + Shredders	52		37		39		36		33	
% EPT	79		51		37		56		58	
% Hydropsychinae of Trichoptera	0		0		0		5		46	
% of internal reference										
Taxa richness	74		82		90		100		64	
EPT richness	87		91		100		91		73	
Biotic index	100		87		83		90		100	
% dominant taxon	53		83		73		100		76	
% Collector (g+ff)	100		58		58		61		66	
% Scrapers + Shredders	100		71		75		69		63	
% EPT	100		65		47		71		73	
% Hydropsychinae of Trichoptera	n.a.		n.a.		n.a.		n.a.		n.a.	
metric score[1]	A	B	A	B	A	B	A	B	A	B
Taxa richness	3	2	3	3	3	3	3	3	2	2
EPT richness	3	3	3	3	3	3	3	3	3	2
Biotic index	3	3	3	2	3	2	3	3	3	3
% dominant taxon	2	2	3	3	3	3	3	3	3	3
% Collector (g+ff)	3	3	3	0	3	0	3	0	3	0
% Scrapers + Shredders	3	3	3	2	3	2	3	2	3	2
% EPT	3	3	2	2	2	1	2	2	2	2
% Hydropsychinae of Trichoptera	3	3	3	3	3	3	3	3	3	3
total score (max = 24)	23	22	23	18	23	17	23	19	22	17
% reference	96	92	96	75	96	71	96	79	92	71
classification *	NON	NON	NON	SLI	NON	SLI	NON	SLI	NON	SLI
use support	FULL		FULL		FULL	PARTIAL	FULL		FULL	PARTIAL

* classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired.

[1] Both the ecoregional reference and the internal reference methods are reported in this table. Column A shows the metric scores calculated on the basis of the Montana Valleys and Foothill Prairies ecoregion criteria. Column B shows the metric scores calculated on the basis of the internal reference for West side Bitterroot streams criteria as in Table 1.

APPENDIX

Macroinvertebrate taxonomic data and metrics

Streams of the Bitterroot Valley

August-September, 1997

Macroinvertebrate Taxonomic Data

East Fork Bitterrroot River EF-01

Taxon	#	%	BI	FFG
Acentrella	12	3.60	4	CG
Baetis tricaudatus	19	5.71	4	CG
Attenella	2	0.60	2	SC
Drunella doddsi	10	3.00	1	SC
Serratella tibialis	15	4.50	2	CG
Timpanoga hecuba	2	0.60	2	CG
Rhithrogena	4	1.20	0	SC
Ameletus	1	0.30	0	CG
TOTAL: EPHEMEROPTERA	65	19.52		
Plumiperla	2	0.60	1	PR
Calineuria californica	14	4.20	2	PR
Claassenia sabulosa	3	0.90	3	PR
Doroneuria	1	0.30	0	PR
Isoperla	1	0.30	3	PR
Perlinodes	5	1.50	1	PR
Pteronarcys	10	3.00	2	SH
TOTAL: PLECOPTERA	36	10.81		
Arctopsyche grandis	21	6.31	2	CF
Hydropsyche	25	7.51	5	CF
Apatania	12	3.60	3	SC
Rhyacophila	1	0.30	1	PR
Neophylax	6	1.80	3	SC
TOTAL: TRICHOPTERA	65	19.52		
Heterlimnius	4	1.20	3	CG
Lara avara	1	0.30	1	SH
Optioservus	20	6.01	5	SC
Zaitzevia	3	0.90	4	CG
TOTAL: COLEOPTERA	28	8.41		
Atherix	6	1.80	5	PR
Simulium	5	1.50	5	CF
Hexatoma	2	0.60	2	PR
TOTAL: DIPTERA	13	3.90		
Cardiocladius	8	2.40	5	PR
Cricotopus Trifascia Gr.	1	0.30	6	CG
Eukiefferiella Gracei Gr.	7	2.10	4	CG
Micropsectra	102	30.63	4	CG
Parametriocnemus	1	0.30	5	CG
Polypedilum	4	1.20	6	CG
Tvetenia Bavarica Gr.	3	0.90	5	CG
TOTAL: CHIRONOMIDAE	126	37.84		
GRAND TOTAL	333	100.00		

Aquatic Macroinvertebrate Data:
Fred Burr Creek FB-01

% of sample used:	40
Subsample size	330
Taxa richness	32
EPT richness	20
Biotic index	3.35
% Dominant taxon	23
% EPT	51
% Collectors (g+f)	57
% Scrapers + Shredders	37
% Hydropsychinae of Trich	0
Metals tolerance index	2.99
Shannon Diversity (log2)	3.93
EPT/Chironomidae	3.78
CTQa	53.69
%Baetidae of Ephemeroptera	34
% Coleoptera	32
% Diptera	2
% Chironomidae	14
% Ephemeroptera	36
% Plecoptera	5
% Trichoptera	11
% multivoltine	19
% univoltine	40
% semivoltine	40

Functional Feeding Grp.	%RA	# taxa
Filterers	6	2
Collector-Gatherers	51	12
Shredders	4	4
Scrapers	33	7
Predators	7	7

Est. total number of organisms	825
Est. number collected per foot	16.5
Est. number collected per minute	412

Aquatic Macroinvertebrate Data:

East Fork Bitterroot River EF-01

% of sample used:	47
Subsample size	330
Taxa richness	34
EPT richness	20
Biotic index	3.51
% Dominant taxon	31
% EPT	50
% Collectors (g+f)	68
% Scrapers + Shredders	20
% Hydropsychinae of Trich	38
Metals tolerance index	2.79
Shannon Diversity (log2)	3.98
EPT/Chironomidae	1.32
CTQa	59.74
%Baetidae of Ephemeroptera	48
% Coleoptera	8
% Diptera	4
% Chironomidae	38
% Ephemeroptera	20
% Plecoptera	11
% Trichoptera	20
% multivoltine	37
% univoltine	39
% semivoltine	23

Functional Feeding Grp.	%RA	# taxa
Filterers	15	3
Collector-Gatherers	52	13
Shredders	3	2
Scrapers	16	6
Predators	13	10

Est. total number of organisms	707
Est. number collected per foot	8
Est. number collected per minute	157

Macroinvertebrate Taxonomic Data

Fred Burr Creek FB-01

Taxon	#	%	BI	FFG
Oligochaeta	6	1.81	10	CG
TOTAL: MISC. TAXA	6	1.81		
Acentrella	1	0.30	4	CG
Baetis tricaudatus	40	12.08	4	CG
Drunella doddsi	11	3.32	1	SC
Drunella grandis	29	8.76	2	CG
Drunella spinifera	1	0.30	0	PR
Serratella tibialis	23	6.95	2	CG
Epeorus albertae	1	0.30	2	SC
Rhithrogena	14	4.23	0	SC
TOTAL: EPHEMEROPTERA	120	36.25		
Plumipera	1	0.30	1	PR
Zapada cinctipes	1	0.30	3	SH
Zapada Oregonensis Gr.	3	0.91	2	SH
Calineuria californica	7	2.11	2	PR
Skwala	3	0.91	3	PR
TOTAL: PLECOPTERA	15	4.53		
Arctopsyche grandis	17	5.14	2	CF
Micrasema	7	2.11	1	SH
Glossosoma	4	1.21	0	SC
Apatania	2	0.60	3	SC
Wormaldia	2	0.60	0	CF
Rhyacophila Brunnea Gr.	2	0.60	2	PR
Neophylax	1	0.30	3	SC
TOTAL: TRICHOPTERA	35	10.57		
Heterlimnius	7	2.11	3	CG
Lara avara	1	0.30	1	SH
Optioservus	76	22.96	5	SC
Zaitzevia	21	6.34	4	CG
TOTAL: COLEOPTERA	105	31.72		
Hexatoma	5	1.51	2	PR
TOTAL: DIPTERA	5	1.51		
Micropsectra	30	9.06	4	CG
Orthocladius	4	1.21	6	CG
Pagastia	3	0.91	1	CG
Rheocricotopus	1	0.30	4	CG
Thienemannimyia	3	0.91	5	PR
Tvetenia Bavarica Gr.	4	1.21	5	CG
TOTAL: CHIRONOMIDAE	45	13.60		
GRAND TOTAL	331	100.00		

Macroinvertebrate Taxonomic Data

Kootenai Creek KC-01

Taxon	#	%	BI	FFG
Baetis tricaudatus	2	0.78	4	CG
Drunella doddsi	23	8.91	1	SC
Drunella grandis	3	1.16	2	CG
Serratella tibialis	10	3.88	2	CG
Epeorus albertae	4	1.55	2	SC
Epeorus longimanus	5	1.94	1	SC
Rhithrogena	94	36.43	0	SC
Ameletus	2	0.78	0	CG
TOTAL: EPHEMEROPTERA	143	55.43		
Zapada cinctipes	2	0.78	3	SH
Calineuria californica	4	1.55	2	PR
Doroneuria	7	2.71	0	PR
Hesperoperla pacifica	13	5.04	1	PR
Megarcys	2	0.78	1	PR
TOTAL: PLECOPTERA	28	10.85		
Arctopsyche grandis	21	8.14	2	CF
Micrasema	3	1.16	1	SH
Glossosoma	1	0.39	0	SC
Agraylea	1	0.39	8	PH
Rhyacophila Betteni Gr.	1	0.39	0	PR
Rhyacophila Brunnea Gr.	5	1.94	2	PR
TOTAL: TRICHOPTERA	32	12.40		
Heterlimnius	3	1.16	3	CG
Optioservus	2	0.78	5	SC
Zaitzevia	19	7.36	4	CG
TOTAL: COLEOPTERA	24	9.30		
Atherix	3	1.16	5	PR
Simulium	5	1.94	5	CF
Hexatoma	4	1.55	2	PR
TOTAL: DIPTERA	12	4.65		
Orthocladius	6	2.33	6	CG
Pagastia	1	0.39	1	CG
Rheocricotopus	3	1.16	4	CG
Tvetenia Bavarica Gr.	9	3.49	5	CG
TOTAL: CHIRONOMIDAE	19	7.36		
GRAND TOTAL	258	100.00		

Aquatic Macroinvertebrate Data:
Kootenai Creek KC-01

% of sample used:	100
Subsample size	258
Taxa richness	29
EPT richness	19
Biotic index	1.55
% Dominant taxon	36
% EPT	79
% Collectors (g+f)	33
% Scrapers + Shredders	52
% Hydropsychinae of Trich	0
Metals tolerance index	2.25
Shannon Diversity (log2)	3.63
EPT/Chironomidae	11
CTQa	50.24
%Baetidae of Ephemeroptera	1
% Coleoptera	9
% Diptera	5
% Chironomidae	7
% Ephemeroptera	55
% Plecoptera	11
% Trichoptera	12
% multivoltine	6
% univoltine	66
% semivoltine	28

Functional Feeding Grp.	%RA	# taxa
Filterers	10	2
Collector-Gatherers	22	10
Shredders	2	2
Scrapers	50	6
Predators	15	8

Est. total number of organisms	258
Est. number collected per foot	12.9
Est. number collected per minute	258

Macroinvertebrate Taxonomic Data

Lost Horse Creek LH-01

Taxon	#	%	BI	FFG
Oligochaeta	1	0.31	10	CG
Acari	1	0.31	5	PA
TOTAL: MISC. TAXA	2	0.62		
Acentrella	5	1.56	4	CG
Baetis tricaudatus	22	6.85	4	CG
Caudatella	1	0.31	0	SC
Drunella doddsi	27	8.41	1	SC
Drunella spinifera	1	0.31	0	PR
Serratella tibialis	2	0.62	2	CG
Cinygmula	2	0.62	0	SC
Rhithrogena	61	19.00	0	SC
TOTAL: EPHEMEROPTERA	121	37.69		
Suwallia	2	0.62	0	PR
Zapada cinctipes	9	2.80	3	SH
Calineuria californica	6	1.87	2	PR
Claassenia sabulosa	1	0.31	3	PR
Hesperoperla pacifica	1	0.31	1	PR
Skwala	2	0.62	3	PR
TOTAL: PLECOPTERA	21	6.54		
Arctopsyche grandis	13	4.05	2	CF
Brachycentrus americanus	2	0.62	1	SC
Micrasema	7	2.18	1	SH
Hydropsyche	2	0.62	5	CF
Agraylea	14	4.36	8	PH
Hydroptila	1	0.31	6	CG
TOTAL: TRICHOPTERA	39	12.15		
Heterlimnius	11	3.43	3	CG
Narpus	1	0.31	2	SH
Optioservus	5	1.56	5	SC
Ordobrevia nubifera	2	0.62	5	CG
Zaitzevia	1	0.31	4	CG
TOTAL: COLEOPTERA	20	6.23		
Atherix	3	0.93	5	PR
Hexatoma	3	0.93	2	PR
TOTAL: DIPTERA	6	1.87		
Eukiefferiella Devonica Gr.	7	2.18	8	CG
Eukiefferiella Pseudomontana Gr.	2	0.62	8	CG
Micropsectra	25	7.79	4	CG
Orthocladius	17	5.30	6	CG
Pagastia	1	0.31	1	CG
Polypedilum	4	1.25	6	CG
Psectrocladius	1	0.31	8	CG
Rheocricotopus	7	2.18	4	CG
Thienemanniella	4	1.25	6	CG
Tvetenia Bavarica Gr.	44	13.71	5	CG
TOTAL: CHIRONOMIDAE	112	34.89		
GRAND TOTAL	321	100.00		

Aquatic Macroinvertebrate Data:
Lost Horse Creek LH-01

% of sample used:	33
Subsample size	321
Taxa richness	39
EPT richness	20
Biotic index	3.24
% Dominant taxon	19
% EPT	56
% Collectors (g+f)	54
% Scrapers + Shredders	36
% Hydropsychinae of Trich	5
Metals tolerance index	2.92
Shannon Diversity (log2)	4.21
EPT/Chironomidae	1.62
CTQa	68.15
%Baetidae of Ephemeroptera	22
% Coleoptera	6
% Diptera	2
% Chironomidae	35
% Ephemeroptera	38
% Plecoptera	7
% Trichoptera	12
% multivoltine	36
% univoltine	50
% semivoltine	14

Functional Feeding Grp.	%RA	# taxa
Filterers	5	2
Collector-Gatherers	49	18
Shredders	5	3
Scrapers	31	6
Predators	6	8

Est. total number of organisms	963
Est. number collected per foot	21.9
Est. number collected per minute	227

MacroinvertebrateTaxonomic Data

North Burnt Fork NBF 02

Taxon	#	%	BI	FFG
Physella	1	0.31	8	SC
Pacifasticus	1	0.31	6	SH
TOTAL: MISC. TAXA	2	0.63		
Baetis tricaudatus	1	0.31	4	CG
Diphetor hageni	1	0.31	5	CG
Leucocruta	3	0.94	4	SC
Paraleptophlebia bicornuta	1	0.31	2	CG
Tricorythodes minutus	20	6.25	4	CG
TOTAL: EPHEMEROPTERA	26	8.13		
Calineuria californica	1	0.31	2	PR
Hesperoperla pacifica	2	0.63	1	PR
Skwala	10	3.13	3	PR
TOTAL: PLECOPTERA	13	4.06		
Glossosoma	1	0.31	0	SC
Hydropsyche	29	9.06	5	CF
Lepidostoma	61	19.06	1	SH
Nectopsyche	1	0.31	2	SH
TOTAL: TRICHOPTERA	92	28.75		
Heterlimnius	3	0.94	3	CG
Optioservus	9	2.81	5	SC
TOTAL: COLEOPTERA	12	3.75		
Chelifera	1	0.31	5	PR
TOTAL: DIPTERA	1	0.31		
Cricotopus Trifascia Gr.	1	0.31	6	CG
Eukiefferiella Gracei Gr.	1	0.31	4	CG
Micropsectra	152	47.50	4	CG
Orthocladius	4	1.25	6	CG
Pagastia	1	0.31	1	CG
Parametriocnemus	2	0.63	5	CG
Polypedilum	7	2.19	6	CG
Thienemannimyia	1	0.31	5	PR
Tvetenia Bavarica Gr.	5	1.56	5	CG
TOTAL: CHIRONOMIDAE	174	54.38		
GRAND TOTAL	320	100.00		

Aquatic Macroinvertebrate Data:
North Burnt Fork NBF 02

% of sample used:	17
Subsample size	320
Taxa richness	26
EPT richness	12
Biotic index	3.57
% Dominant taxon	48
% EPT	41
% Collectors (g+f)	71
% Scrapers + Shredders	24
% Hydropsychinae of Trich	32
Metals tolerance index	2.06
Shannon Diversity (log2)	2.68
EPT/Chironomidae	.75
CTQa	79.96
%Baetidae of Ephemeroptera	8
% Coleoptera	4
% Diptera	<1
% Chironomidae	54
% Ephemeroptera	8
% Plecoptera	4
% Trichoptera	29
% multivoltine	44
% univoltine	51
% semivoltine	5

Functional Feeding Grp.	%RA	# taxa
Filterers	9	1
Collector-Gatherers	62	13
Shredders	20	3
Scrapers	4	4
Predators	5	5

Est. total number of organisms	5440
Est. number collected per foot	201
Est. number collected per minute	3627

Macroinvertebrate Taxonomic Data

Rye Creek RC-01

Taxon	#	%	BI	FFG
Oligochaeta	1	0.33	10	CG
Acari	1	0.33	5	PA
TOTAL: MISC. TAXA	2	0.65		
Baetis tricaudatus	13	4.25	4	CG
Diphetor hageni	2	0.65	5	CG
Drunella doddsi	1	0.33	1	SC
Drunella grandis	10	3.27	2	CG
Serratella tibialis	7	2.29	2	CG
Timpanoga hecuba	1	0.33	2	CG
Leucocruta	4	1.31	4	SC
Tricorythodes minutus	26	8.50	4	CG
TOTAL: EPHEMEROPTERA	64	20.92		
Zapada Oregonensis Gr.	1	0.33	2	SH
Skwala	5	1.63	3	PR
Pteronarcella	2	0.65	4	SH
TOTAL: PLECOPTERA	8	2.61		
Arctopsyche grandis	1	0.33	2	CF
Brachycentrus americanus	8	2.61	1	SC
Hydropsyche	13	4.25	5	CF
Apatania	8	2.61	3	SC
TOTAL: TRICHOPTERA	30	9.80		
Heterlimnius	11	3.59	3	CG
Optioservus	48	15.69	5	SC
Zaitzevia	1	0.33	4	CG
TOTAL: COLEOPTERA	60	19.61		
Limnophora	1	0.33	6	PR
Simulium	8	2.61	5	CF
Dicranota	1	0.33	3	PR
Hexatoma	3	0.98	2	PR
TOTAL: DIPTERA	13	4.25		
Eukiefferiella Gracei Gr.	48	15.69	4	CG
Micropsectra	42	13.73	4	CG
Orthocladius	9	2.94	6	CG
Pagastia	2	0.65	1	CG
Parametriocnemus	21	6.86	5	CG
Polypedilum	2	0.65	6	CG
Thienemannimyia	2	0.65	5	PR
Tvetenia Bavarica Gr.	3	0.98	5	CG
TOTAL: CHIRONOMIDAE	129	42.16		
GRAND TOTAL	306	100.00		

Aquatic Macroinvertebrate Data:
Rye Creek RC-01

% of sample used:	17
Subsample size	306
Taxa richness	32
EPT richness	15
Biotic index	4.08
% Dominant taxon	16
% EPT	33
% Collectors (g+f)	72
% Scrapers + Shredders	24
% Hydropsychinae of Trich	43
Metals tolerance index	4.31
Shannon Diversity (log2)	4.00
EPT/Chironomidae	.79
CTQa	71.69
%Baetidae of Ephemeroptera	23
% Coleoptera	20
% Diptera	4
% Chironomidae	42
% Ephemeroptera	21
% Plecoptera	3
% Trichoptera	10
% multivoltine	37
% univoltine	40
% semivoltine	23

Functional Feeding Grp.	%RA	# taxa
Filterers	7	3
Collector-Gatherers	65	16
Shredders	1	2
Scrapers	23	5
Predators	4	5

Est. total number of organisms	1836
Est. number collected per foot	1224
Est. number collected per minute	51

Macroinvertebrate Taxonomic Data

Skalkaho Creek SC-01

Taxon	#	%	BI	FFG
Acentrella	11	3.22	4	CG
Baetis tricaudatus	44	12.87	4	CG
Drunella doddsi	16	4.68	1	SC
Drunella grandis	13	3.80	2	CG
Serratella tibialis	11	3.22	2	CG
Epeorus albertae	3	0.88	2	SC
Rhithrogena	33	9.65	0	SC
Ameletus	4	1.17	0	CG
Tricorythodes minutus	1	0.29	4	CG
TOTAL: EPHEMEROPTERA	136	39.77		
Amphinemura	1	0.29	2	SH
Zapada cinctipes	6	1.75	3	SH
Calineuria californica	6	1.75	2	PR
Hesperoperla pacifica	6	1.75	1	PR
Skwala	7	2.05	3	PR
TOTAL: PLECOPTERA	26	7.60		
Arctopsyche grandis	25	7.31	2	CF
Brachycentrus americanus	1	0.29	1	SC
Glossosoma	4	1.17	0	SC
Hydropsyche	11	3.22	5	CF
Lepidostoma	4	1.17	1	SH
Rhyacophila Angelita Gr.	1	0.29	0	PR
TOTAL: TRICHOPTERA	46	13.45		
Heterlimnius	5	1.46	3	CG
Optioservus	21	6.14	5	SC
Zaitzevia	5	1.46	4	CG
TOTAL: COLEOPTERA	31	9.06		
Ceratopogonidae	1	0.29	6	PR
Simulium	1	0.29	5	CF
Hexatoma	4	1.17	2	PR
TOTAL: DIPTERA	6	1.75		
Eukiefferiella Gracei Gr.	17	4.97	4	CG
Micropsectra	45	13.16	4	CG
Orthocladius	2	0.58	6	CG
Pagastia	3	0.88	1	CG
Polypedilum	3	0.88	6	CG
Rheocricotopus	1	0.29	4	CG
Thienemannimyia	1	0.29	5	PR
Tvetenia Bavarica Gr.	25	7.31	5	CG
TOTAL: CHIRONOMIDAE	97	28.36		
GRAND TOTAL	342	100.00		

Aquatic Macroinvertebrate Data:
Skalkaho Creek SC-01

% of sample used:	17
Subsample size	330
Taxa richness	34
EPT richness	20
Biotic index	3.03
% Dominant taxon	13
% EPT	61
% Collectors (g+f)	66
% Scrapers + Shredders	26
% Hydropsychinae of Trich	24
Metals tolerance index	3.14
Shannon Diversity (log2)	4.29
EPT/Chironomidae	2.14
CTQa	62
%Baetidae of Ephemeroptera	40
% Coleoptera	9
% Diptera	2
% Chironomidae	28
% Ephemeroptera	40
% Plecoptera	8
% Trichoptera	13
% multivoltine	34
% univoltine	46
% semivoltine	20

Functional Feeding Grp.	%RA	# taxa
Filterers	11	3
Collector-Gatherers	56	15
Shredders	3	3
Scrapers	23	6
Predators	8	7

Est. total number of organisms	1980
Est. number collected per foot	41
Est. number collected per minute	660

Macroinvertebrate Taxonomic Data

Sweathouse Creek SW01

Taxon	#	%	BI	FFG
Pacifasticus	1	0.29	6	SH
Acari	1	0.29	5	PA
TOTAL: MISC. TAXA	2	0.58		
Baetis tricaudatus	5	1.46	4	CG
Diphetor hageni	7	2.04	5	CG
Drunella coloradensis	1	0.29	0	CG
Drunella doddsi	3	0.87	1	SC
Drunella grandis	35	10.20	2	CG
Serratella tibialis	9	2.62	2	CG
Cinygmula	1	0.29	0	SC
Epeorus longimanus	10	2.92	1	SC
Leucocruta	2	0.58	4	SC
Rhithrogena	2	0.58	0	SC
TOTAL: EPHEMEROPTERA	75	21.87		
Sweltsa	1	0.29	0	PR
Amphinemura	2	0.58	2	SH
Calineuria californica	1	0.29	2	PR
Pteronarcella	1	0.29	4	SH
TOTAL: PLECOPTERA	5	1.46		
Arctopsyche grandis	17	4.96	2	CF
Micrasema	1	0.29	1	SH
Glossosoma	12	3.50	0	SC
Apatania	2	0.58	3	SC
Wormaldia	2	0.58	0	CF
Rhyacophila Betteni Gr.	1	0.29	0	PR
Rhyacophila Brunnea Gr.	1	0.29	2	PR
Neophylax	5	1.46	3	SC
TOTAL: TRICHOPTERA	41	11.95		
Heterlimnius	22	6.41	3	CG
Optioservus	89	25.95	5	SC
Zaitzevia	72	20.99	4	CG
TOTAL: COLEOPTERA	183	53.35		
Simulium	1	0.29	5	CF
Hexatoma	3	0.87	2	PR
Hesperoconopa	1	0.29	1	UN
TOTAL: DIPTERA	5	1.46		
Brillia	3	0.87	4	SH
Micropsectra	9	2.62	4	CG
Rheocricotopus	1	0.29	4	CG
Thienemannimyia	2	0.58	5	PR
Tvetenia Bavarica Gr.	17	4.96	5	CG
TOTAL: CHIRONOMIDAE	32	9.33		
GRAND TOTAL	343	100.00		

Aquatic Macroinvertebrate Data:
Sweathouse Creek SW01

% of sample used:	23
Subsample size	330
Taxa richness	35
EPT richness	22
Biotic index	3.50
% Dominant taxon	26
% EPT	37
% Collectors (g+f)	58
% Scrapers + Shredders	39
% Hydropsychinae of Trich	0
Metals tolerance index	293
Shannon Diversity (log2)	3.64
EPT/Chironomidae	3.78
CTQa	53.00
%Baetidae of Ephemeroptera	16
% Coleoptera	53
% Diptera	1
% Chironomidae	9
% Ephemeroptera	22
% Plecoptera	1
% Trichoptera	12
% multivoltine	10
% univoltine	31
% semivoltine	59

Functional Feeding Grp.	%RA	# taxa
Filterers	6	3
Collector-Gatherers	52	10
Shredders	2	5
Scrapers	37	9
Predators	3	6

Est. total number of organisms	1414
Est. number collected per foot	28
Est. number collected per minute	471

Macroinvertebrate Taxonomic Data

Three Mile Creek TM-01

Taxon	#	%	BI	FFG
Nematoda	1	0.33	5	OM
Oligochaeta	1	0.33	10	CG
TOTAL: MISC. TAXA	2	0.66		
Baetis tricaudatus	101	33.22	4	CG
Diphetor hageni	1	0.33	5	CG
Serratella tibialis	9	2.96	2	CG
Leucocruta	19	6.25	4	SC
Paraleptophlebia	2	0.66	1	CG
Tricorythodes minutus	13	4.28	4	CG
TOTAL: EPHEMEROPTERA	145	47.70		
Amphinemura	1	0.33	2	SH
Zapada cinctipes	2	0.66	3	SH
Hesperoperla pacifica	9	2.96	1	PR
Skwala	3	0.99	3	PR
Pteronarcella	2	0.66	4	SH
TOTAL: PLECOPTERA	17	5.59		
Glossosoma	1	0.33	0	SC
Hydropsyche	3	0.99	5	CF
TOTAL: TRICHOPTERA	4	1.32		
Cleptelmis	1	0.33	4	CG
Heterlimnius	4	1.32	3	CG
Optioservus	23	7.57	5	SC
Zaitzevia	6	1.97	4	CG
TOTAL: COLEOPTERA	34	11.18		
Chelifera	2	0.66	5	PR
Simulium	11	3.62	5	CF
Dicranota	2	0.66	3	PR
Ormosia	1	0.33	6	CG
Tipula	1	0.33	4	SH
TOTAL: DIPTERA	17	5.59		
Cricotopus Trifascia Gr.	9	2.96	6	CG
Eukiefferiella Devonica Gr.	1	0.33	8	CG
Eukiefferiella Pseudomontana Gr.	10	3.29	8	CG
Micropsectra	20	6.58	4	CG
Orthocladius	19	6.25	6	CG
Pagastia	1	0.33	1	CG
Parametriocnemus	3	0.99	5	CG
Thienemanniella	1	0.33	6	CG
Tvetenia Bavarica Gr.	21	6.91	5	CG
TOTAL: CHIRONOMIDAE	85	27.96		
GRAND TOTAL	304	100.00		

Aquatic Macroinvertebrate Data:
Three Mile Creek TM-01

% of sample used:	50
Subsample size	304
Taxa richness	33
EPT richness	13
Biotic index	4.34
% Dominant taxon	33
% EPT	55
% Collectors (g+f)	78
% Scrapers + Shredders	16
% Hydropsychinae of Trich	.75
Metals tolerance index	4.17
Shannon Diversity (log2)	3.75
EPT/Chironomidae	1.95
CTQa	75.79
%Baetidae of Ephemeroptera	70
% Coleoptera	11
% Diptera	6
% Chironomidae	28
% Ephemeroptera	48
% Plecoptera	6
% Trichoptera	1
% multivoltine	47
% univoltine	38
% semivoltine	15

Functional Feeding Grp.	%RA	# taxa
Filterers	5	2
Collector-Gatherers	74	19
Shredders	2	4
Scrapers	14	3
Predators	5	4

Est. total number of organisms	608
Est. number collected per foot	28
Est. number collected per minute	486

Macroinvertebrate Taxonomic Data

West Fork Bitterroot River WF-01

Taxon	#	%	BI	FFG
Oligochaeta	1	0.50	10	CG
TOTAL: MISC. TAXA	1	0.50		
Acentrella	1	0.50	4	CG
Baetis bicaudatus	1	0.50	2	CG
Drunella doddsi	7	3.48	1	SC
Serratella tibialis	18	8.96	2	CG
Cinygmula	1	0.50	0	SC
Rhithrogena	23	11.44	0	SC
TOTAL: EPHEMEROPTERA	51	25.37		
Sweltsa	2	1.00	0	PR
Calineuria californica	6	2.99	2	PR
Claassenia sabulosa	2	1.00	3	PR
Hesperoperla pacifica	3	1.49	1	PR
Pteronarcys	24	11.94	2	SH
TOTAL: PLECOPTERA	37	18.41		
Arctopsyche grandis	12	5.97	2	CF
Glossosoma	1	0.50	0	SC
Hydropsyche	13	6.47	5	CF
Apatania	1	0.50	3	SC
Dicosmoecus gilvipes	1	0.50	2	SC
TOTAL: TRICHOPTERA	28	13.93		
Heterlimnius	2	1.00	3	CG
Optioservus	7	3.48	5	SC
TOTAL: COLEOPTERA	9	4.48		
Atherix	21	10.45	5	PR
Hexatoma	1	0.50	2	PR
TOTAL: DIPTERA	22	10.95		
Brillia	1	0.50	4	SH
Eukiefferiella Pseudomontana Gr.	1	0.50	8	CG
Micropsectra	50	24.88	4	CG
Tvetenia Bavarica Gr.	1	0.50	5	CG
TOTAL: CHIRONOMIDAE	53	26.37		
GRAND TOTAL	201	100.00		

Aquatic Macroinvertebrate Data:
West Fork Bitterroot River WF-01

% of sample used:	100
Subsample size	201
Taxa richness	25
EPT richness	16
Biotic index	2.92
% Dominant taxon	25
% EPT	58
% Collectors (g+f)	50
% Scrapers + Shredders	33
% Hydropsychinae of Trich	.46
Metals tolerance index	2.38
Shannon Diversity (log2)	3.57
EPT/Chironomidae	2.19
CTQa	52.40
%Baetidae of Ephemeroptera	4
% Coleoptera	4
% Diptera	11
% Chironomidae	26
% Ephemeroptera	25
% Plecoptera	18
% Trichoptera	14
% multivoltine	22
% univoltine	50
% semivoltine	28

Functional Feeding Grp.	%RA	# taxa
Filterers	12	2
Collector-Gatherers	37	8
Shredders	12	2
Scrapers	20	7
Predators	17	6

Est. total number of organisms	201
Est. number collected per foot	2
Est. number collected per minute	34

TABLE A. Functional Feeding Groups

Abbreviation	Description
CF	Collector - filterer
CG	Collector - gatherer
OM	Omnivore
PA	Parasite
PR	Predator
SC	Scraper
UN	Unknown
SH	Shredder

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BIOASSESSMENT AND HABITAT EVALUATION OF O'FALLON CREEK, PENNEL CREEK, AND SANDSTONE CREEK

Fallon, Prairie, and Custer Counties, Montana

June 2001

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report prepared for
The Montana Department of Environmental Quality
Helena, Montana

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May 2002

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INTRODUCTION

Benthic assemblages are aptly applied to aquatic bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

Multimetric approaches to bioassessment use attributes of the assemblage in an integrated way to measure biotic integrity, defined by Karr and Dudley as "...the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitats within a region." The additive multimetric approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of aquatic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1995). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998). The first element is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied must be done, to assist in the interpretation of metric outcomes.

Relevant habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by quantities of organic materials, nutrients, metals, or other toxicants might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment. Habitat assessment data is even more important in the plains ecoregions, where the relationships between habitat variables and benthic community characteristics remain largely unknown.

This report summarizes data collected in late June 2001, from O'Fallon Creek and tributary systems, using a multimetric method of analysis, an adaptation of the U.S. EPA's Rapid Bioassessment Protocols (RBP III) (Plafkin et al. 1989). Invertebrates were collected at eleven sites in this watershed, which is tributary to the Yellowstone River located in the Northwestern Great Plains ecoregion (Woods et al. 1999).

Selection of bioassessment metrics, assessment of habitat, and evaluation of benthic community attributes for this study were not straightforward tasks. The standard operating procedures manual for aquatic invertebrate sampling and analysis of the Montana Department of Environmental Quality (Montana DEQ) (Bukantis 1998) recommends the use of ten metrics for assessing biota of streams in the Montana plains ecoregions, and a habitat assessment incorporating ten habitat measures thought to be related to disturbance and biology in streams with glide and pool prevalence. Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between disturbance, habitat measures, and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of independent measures of human-caused disturbance, habitat assessment elements, and biotic metrics and a test of the presumed relationship between them. Assurance of the validity of association between disturbance, habitat measures, and biotic metrics is particularly compelling in the Montana plains ecoregions through which O'Fallon Creek and its tributaries flow, since impairment of the biotic health of streams in this region is generally the result of non-point sources related to human-caused disturbances. Agricultural activities, cattle grazing, and flow alteration are predominant causes of stream degradation. The benthic assemblages of the plains ecoregions and the performance of the recommended bioassessment metrics have not yet been examined thoroughly enough to determine whether or not the individual metrics or their integrated scores can discriminate impaired conditions from good biotic health. This author (Bollman 1998) evaluated bioassessment metrics for the Montana valleys and foothill prairies ecoregion, and found that many metrics recommended for use in that region were not accurate in discriminating impaired from unimpaired conditions. However, analysis of benthic communities based on the taxonomic composition of the assemblages collected is probably a valid approach to bioassessment in the plains ecoregions. Thus, while bioassessment scores must be regarded cautiously, observations based on characteristics of taxa present in samples is likely to reveal reliable information about water quality and habitat condition. To maximize the reliability of assessments, Montana DEQ requires this type of information in addition to bioassessment indices and scores to assist in management decisions.

Relationships between human-caused disturbance and the measures comprising the habitat assessment index used in this study are not completely understood, and have not yet been thoroughly investigated in the Montana plains ecoregions. Recently, Fore and Bollman (2000) have studied the relationships between independent measures of disturbance, habitat features, and biotic metrics for three ecoregions of Idaho. This study found that many habitat assessment measures are either not strongly related to human-caused disturbance or they do not appear to have an appreciable effect on biotic metrics. Since neither the habitat measures nor the bioassessment metrics used at this time in the Montana plains ecoregions have been subjected to testing procedures, it is impossible to say with certainty that the habitat measures used here are associated with anthropogenic disturbance, and further, whether those habitat measures are associated with features of the biological communities of the streams in the O'Fallon Creek watershed represented by the bioassessment metrics. Therefore, bioassessment and habitat assessment scores presented in this report must be considered tentative, and the data should be reconsidered in the future, after research has been done to better elucidate these relationships. Conclusions and observations based upon characteristics of the taxa present in samples is likely to be the most reliable source of information concerning water quality and instream and riparian habitat conditions for purposes of resource management.

METHODS

Aquatic invertebrates were sampled from eleven sites in the O'Fallon Creek watershed on June 26, 27, and 28, 2001. Sampling site locations, identifiers, and descriptions are given in Table 1.

Table 1. Sampling site identifiers, descriptions and locations in the O'Fallon Creek watershed, June 2001.

Site Identifier	Location	GPS location
AF-7	O'Fallon Creek: at Willard crossing	46° 28' 03.5" N 104° 46' 33.28"W (2001) 46° 11' 08" N 104° 43' 58"W (1999)
AF-3	O'Fallon Creek	46° 16' 51.5" N 104° 45'27.23"W
AF-5	O'Fallon Creek:	46° 25' 14.15" N 104° 45'41.72"W
BF-8	O'Fallon Creek: at Mildred	46° 41' 23.0" N 104° 58'40.6"W
BF-10	O'Fallon Creek: near mouth	46° 43' 21.8" N 105° 01'42.8"W
AS-2	Sandstone Creek: above Leibec bridge	46° 24' 09.93" N 104° 25' 41.20" W
AS-5	Sandstone Creek: Stefles bridge	46° 24' 37.21"N 104° 32' 43.54" W
CF-11	Sandstone Creek: Bill Bickle bridge near state section	46° 29.081'N 104° 43.929'W
SS-3	South Sandstone Creek: about 1000 ft. from mouth. South of Plevna.	46° 24.248'N 104°31.443'W
DF-6	Pennel Creek	46° 32' 28.5"N 104° 37' 35.5"W
DF-10	Pennel Creek	46° 33' 46.3"N 104° 51' 09.5" W

In addition to invertebrate sample collection, habitat quality was visually evaluated at each site and reported by means of the habitat assessment protocols recommended by Bukantis (1998) for streams with prevalent glides and pools. Invertebrate samples and the associated habitat data were delivered to Rhithron Biological Associates, Missoula, Montana, for laboratory and data analyses. In the laboratory, the RBP III sorting method was used to obtain subsamples of 300 (+/- 10%) organisms from each sample when possible. When samples contained fewer than 300 total organisms, all invertebrates present were used. Community structure, function, and sensitivity to impact were characterized for each subsample using a battery of ten attributes, or metrics, recommended by Bukantis (1998) for streams of the Montana plains ecoregions (Table 2). Metric results were compared to reference criteria provisionally established by Montana DEQ for streams of the Plains ecoregions. Actual metric values from each sample were compared to ecoregional reference values to obtain scores. Scores for all metrics were combined, and a total bioassessment score was expressed as a percentage of the maximum possible score. Total bioassessment scores were interpreted in terms of aquatic life or other uses according to guidelines established by Montana DEQ (Bukantis 1998) and elaborated in Table 3 in this report.

Table 2. Provisional metrics and scoring criteria for the Montana plains ecoregions; the Montana plains ecoregions reference. (Bukantis, 1998).

	Score			
Metric	**3**	**2**	**1**	**0**
Taxa richness	>24	24 - 18	18 – 12	<12
EPT richness	>8	8 – 6	5 – 3	<3
Biotic Index	<5	5 – 6	6 – 7	>7
% Dominant taxon	<30	30 – 45	45 – 60	>60
% Collectors	<60	60 – 80	80 – 95	>95
% EPT	>50	50 – 30	30 – 10	<10
Shannon H (log2)	>3.0	3.0 – 2.4	2.4 – 1.8	<1.8
% Scrapers + shredders	>30	30 – 15	15 – 3	<3
# Predator taxa	>5	4 – 5	3 – 4	<3
% Multivoltine	<40	40 - 60	60 – 80	>80

Table 3. Criteria for the assignment of support classifications / standards violation thresholds (Bukantis, 1998)

% Comparability to reference	**Use support**
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

RESULTS

Habitat Assessment

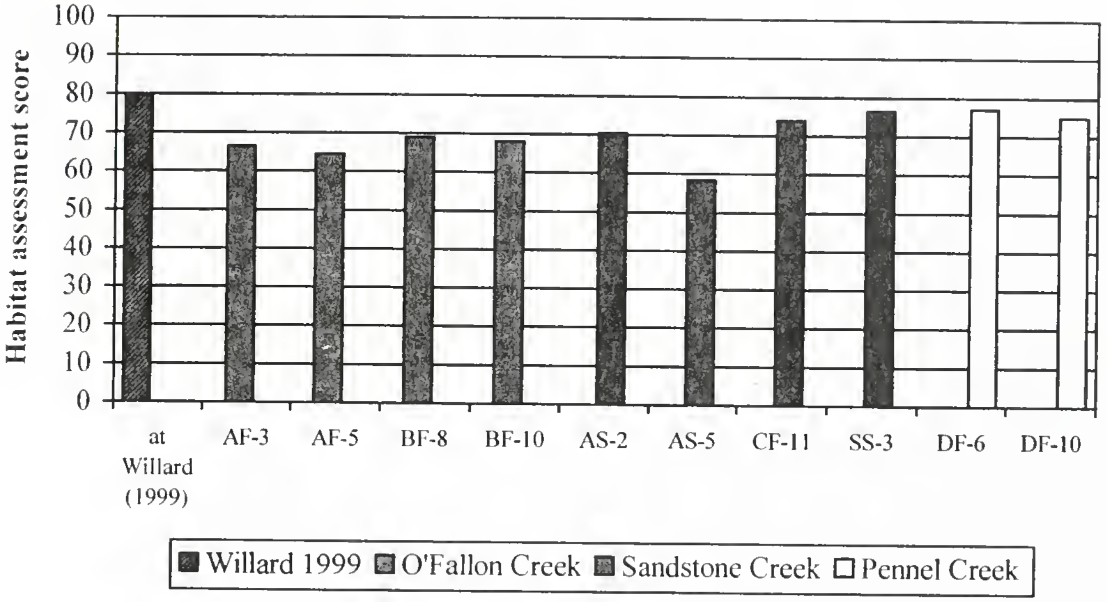
Table 4 shows the habitat parameters evaluated, parameter scores and overall habitat evaluations for the eleven sites studied. Figure 1 graphically compares total habitat assessment scores for the studied sites.

Table 4. Stream and riparian habitat assessment, glide/pool prevalence: O'Fallon Creek watershed. June 2001. Habitat was assessed at the Willard site in 1999; that data is italicized in the table.

Max. score	Location:	**O'Fallon Creek**					**Sandstone Creek**				**Pennel Creek**	
		at Willard (1999)	**AF-3**	**AF-5**	**BF-8**	**BF-10**	**AS-2**	**AS-5**	**CF-11**	**SS-3**	**DF-6**	**DF-10**
	Parameter											
20	Bottom substrate	*15*	13	13	13	13	13	11	11	12	16	14
20	Pool substrate	*16*	13	13	16	16	16	12	n.a.	14	14	16
20	Pool variability	*18*	11	10	15	16	16	11	16	15	16	10
20	Channel alteration	*17*	19	16	17	10	17	12	20	16	16	20
20	Sediment deposition	*15*	16	16	16	16	15	12	18	18	13	16
20	Channel sinuosity	*15*	15	15	13	18	12	11	12	10	15	20
20	Flow status	*18*	18	18	20	19	19	19	13	18	20	16
10 / 10	Bank vegetation	*8 / 8*	6 / 6	6 / 6	6 / 6	6 / 6	6 / 8	6 / 7	10 / 10	10 / 10	10 / 10	9 / 9
10 / 10	Bank stability	*7 / 7*	8 / 8	8 / 8	8 / 8	8 / 8	4 / 5	5 / 4	10 / 10	10 / 10	10 / 10	9 / 9
10 / 10	Riparian zone width	*8 / 8*	0 / 0	0 / 0	0 / 0	0 / 0	5 / 5	4 / 3	2 / 2	5 / 5	2 / 2	1 / 1
200	TOTAL SCORE	*160*	133	129	138	136	141	117	134	153	154	150
PERCENT OF MAXIMUM:		***80***	**66.5**	**64.5**	**69**	**68**	**70.5**	**58.5**	**74**	**76.5**	**77**	**75**
CONDITION[1]		*SUB*	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB	SUB

[1] (OPT)=Optimal >81%, (SUB)=Sub-Optimal 75-56%, (MARG)=Marginal 49-29%, (POOR)=Poor <23%. (Plafkin et al. 1989).

Figure 1. Total habitat assessment scores for eleven sites in the O'Fallon Creek watershed. June 2001. Habitat was assessed at Willard in 1999.



Overall habitat assessment scores indicated that habitat conditions were sub-optimal at 10 of the 11 sites studied. Habitat assessments were not available for O'Fallon Creek at Willard in 2001; data from sampling in 1999 was used.

In 1999, substrate at the Willard site was reported to be sub-optimal, with logs present instream, and submerged aqueous vegetation and rocks characterizing riffle habitats. Some silt deposition was noted. Pool substrates were described as "hard gravel".

Habitat conditions appeared to be fairly consistent longitudinally in O'Fallon Creek in 2001. Substrate in sampled riffles was reported to be mainly sand and gravel at the upstream sites (AF-3, AF-5) while cobble was added to the mix at the downstream sites (BF-8, BF-10). Pool substrates were primarily muddy at the upstream sites, some cobble was also present in pools at the lower sites. The variability of pool morphology was perceived to increase longitudinally; thus, instream habitat appears to have increased in heterogeneity from the upstream sites to the downstream locations. Sediment deposition was generally minor at all sites studied.

Channel alteration increased in the downstream direction, with optimal scores at the upstream sites degenerating to a marginal score at the lowermost site, BF-10. A related feature, channel sinuosity also deteriorated from a sub-optimal condition at sites AF-3 and AF-5 to a marginal condition at site BF-10. While bank stability and vegetative cover were good in all reaches, little or no riparian vegetation was present in any evaluated reach of O'Fallon Creek.

Gravel and sand characterized riffles in Sandstone Creek, with variable pool morphologies present; instream habitats were apparently quite diverse. Sediment deposition was moderate at the two upstream sites (AS-2, AS-5), but only minor at the lowest site (CF-11). Few channelized sections were noted in any reach, and sinuosity was perceived to be appropriate. Some incisement of the channel was noted at the two upper sites. Flow conditions were judged good in the upper two reaches, but the field investigator noted that wastewater releases may affect flows monthly in these locations. Sub-optimal flow status was reported in the lowermost reach.

Streambank vegetation was "less robust and diverse" in the uppermost reach than in the other evaluated reaches of Sandstone Creek; few woody plants were noted at site AS-5. Bank stability was marginal at both upper sites and banks were described as incised, but no major movement of streambank soils were noted. By contrast, the lower site was perceived to have optimal bank vegetative protection and optimal stability. Poor riparian zone width was noted at the lower site, and incisement limited riparian zone potential at the upper two sites.

Habitat conditions at the single site on South Sandstone Creek were scored similarly to the sites on the mainstem. Instream habitat was generally judged sub-optimal, but some diversity was apparently perceived. The site was noted to be unaffected by appreciable sediment deposition. No channel alteration was noted, other than the presence of an upstream bridge, but sinuosity was judged marginal. Flow status was rated optimal. Streambanks were perceived to be well-vegetated and stable, but the riparian zone width was rated marginal.

The two sites on Pennel Creek received slightly higher scores for overall habitat quality than sites on the other streams studied. Instream habitat conditions were optimal at the upper Pennel Creek site (DF-6), with abundant vegetation and snags providing some diversity. Sub-optimal instream conditions were noted at the lower site (DF-10), though pool substrate was perceived to be a more diverse mix here. Morphological variability of pools was only marginal at the lower site. Sediment deposition was noted to be moderate at the upper site, but minor at the downstream site. Bank vegetation protection and associated bank stability were optimal at both sites on Pennel Creek, but riparian zone functional potential was judged poor, with widths severely limited.

Bioasssessment

Macroinvertebrate taxa lists, metric results and other information for each sample are given in the Appendix. Table 3 summarizes the metric battery used in the Plains ecoregional reference method, and Table 4 shows the Montana DEQ criteria for assignment of use-support categories. Breakdown of scores for each metric calculated from the O'Fallon Creek watershed aquatic invertebrate samples is presented in Table 5. Figure 2 compares the total bioassessment scores for all eleven sites when the aquatic invertebrate data was evaluated using the Montana DEQ plains ecoregions reference and metric battery, which are considered provisional. It is important to note that neither the metric battery used here nor any of its components has been tested for discriminatory power, accuracy, or precision in Plains ecoregions streams.

Bioassessment scores calculated by this method indicate partial support of designated uses at all but one of the studied sites. At site DF-6, the uppermost site sampled on Pennel Creek, uses were not supported, and severe impairment of biotic health was indicated. Scores at the other 10 sites indicated a range from slight impairment of biotic health in the lower sampled reaches of O'Fallon Creek, to moderate impairment in the upper sampled reaches of O'Fallon Creek, at all sites in the Sandstone Creek drainage, and at the lower site on Pennel Creek.

At the upper sites on O'Fallon Creek (at Willard, AF-3, AF-5), high biotic index values and low abundance of scraping and shredding taxa were the main reason for the lower assessment score. In the lower reaches, EPT richness was much lower than expected at all 3 sites and biotic index values were high. Another impact on the bioassessment score was the virtual absence of shredders and scrapers in these reaches.

The Sandstone Creek watershed and Pennel Creek both had generally lower bioassessment scores than did O'Fallon Creek. EPT richness was very low at all sites in these drainages, and biotic index values were high. At most sites, a single taxon dominated in the sample; dominant taxon abundance was as high as 81%. The general measure of diversity, Shannon H, was much lower than expected at every site in these two watersheds. Shredders and scrapers were all but absent from the reaches studied. Scores at Pennel Creek sites were further diminished by a lack of predator taxa, and generally low taxa richness.

Aquatic invertebrate communities

High biotic index scores in the upper reaches of O'Fallon Creek suggest that water quality was impaired by nutrient and/or organic pollution or that water temperatures were relatively warm. The relatively high taxa richness at all sites on O'Fallon Creek could be interpreted as evidence of organic enrichment of these sites. At the Willard site in 2001, the single mayfly taxon collected was the highly tolerant *Caenis latipennis*; it represented 38% of the sampled assemblage. Other abundant taxa were the

Figure 2. Total bioassessment scores, expressed as percent of maximum score, for eleven sites in the O'Fallon Creek watershed. June 2001. Additional data from the site at Willard is from a 1999 study. Montana plains ecoregions reference used for comparison (Bukantis 1998).

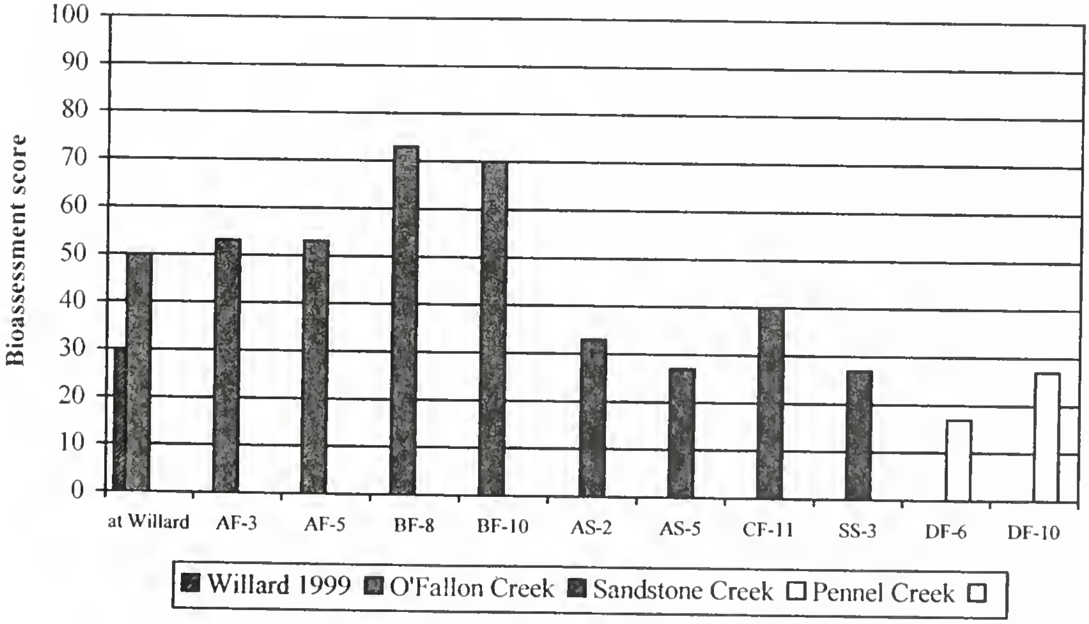


Table 5. Aquatic bioassessment metrics and scores for eleven sites in the O'Fallon Creek watershed. June 2001. Data from a 1999 study was available for the site at Willard; this data is italicized in the table. Montana plains ecoregions reference (Bukantis 1998).

	O'Fallon Creek						**Sandstone Creek**				**Pennel Creek**	
VALUES	***at Willard (1999)***	**at Willard**	**AF-3**	**AF-5**	**BF-8**	**BF-10**	**AS-2**	**AS-5**	**CF-11**	**SS-3**	**DF-6**	**DF-10**
Taxa richness	*20*	22	21	20	27	27	20	19	17	18	15	17
EPT richness	*2*	2	5	2	9	8	3	1	2	2	0	3
Biotic Index	*6.26*	6.80	7.21	6.47	6.71	6.43	6.26	6.53	6.73	7.66	6.35	6.17
% dominant taxon	*38*	38	27	33	25	28	81	67	36	66	50	75
% collectors	*97*	69	76	76	77	67	17	97	94	90	97	92
% EPT	*14*	38	31	22	49	71	1	6	27	1	0	6
Shannon diversity	*2.30*	2.39	2.71	2.59	2.96	2.83	0.87	1.97	2.15	1.46	2.18	1.10
% Shredders + scrapers	*<1*	<1	<1	0	13	5	<1	<1	0	1	0	0
# Predator taxa	*2*	5	4	6	6	3	4	3	4	5	2	3
% Multivoltine	*48*	27	44	28	41	33	66	15	38	2	74	11
SCORES												
Taxa richness	*2*	2	2	2	3	3	2	2	1	2	1	1
EPT richness	*0*	0	1	0	3	2	1	0	0	0	0	1
Biotic Index	*1*	1	0	1	1	1	1	1	1	0	1	1
% dominant taxon	*2*	2	3	2	3	3	0	0	2	0	1	0
% collectors	*0*	2	2	2	2	2	3	0	1	1	0	1
% EPT	*1*	2	2	1	2	3	0	0	1	0	0	0
Shannon diversity	*1*	1	2	2	2	2	0	1	1	0	1	0
% Shredders + scrapers	*0*	0	0	0	1	1	0	0	0	0	0	0
# Predator taxa	*0*	2	2	3	3	1	2	1	2	2	0	1
% Multivoltine	*2*	3	2	3	2	3	1	3	3	3	1	3
TOTAL SCORE	*9*	15	16	16	22	21	10	8	12	8	5	8
PERCENT MAX.	***30***	**50**	**53**	**53**	**73**	**70**	**33**	**27**	**40**	**27**	**17**	**27**
USE SUPPORT[1]	***part***	**part**	**part**	**part**	**part**	**part**	**part**	**part**	**part**	**part**	**non**	**part**

[1] See Table 3 for Use Support criteria.

midge *Paratanytarsus* sp., and the blackfly *Simulium* sp. This assemblage suggests abundant organic material in the form of fine deposits as well as suspended in the flow. Sandy substrates at the site are indicated by the presence of the midge *Pseudochironomus* sp.

In 1999, the site at Willard was sampled as part of another Montana DEQ study (Bollman 2000). The 1999 sample from this site produced a bioassessment score of 30% of maximum, while the 2001 sample scored 50% of maximum. Samples scored similarly for the number of taxa collected, number of EPT taxa collected, biotic index value, dominance, diversity, and functional components. There were differences in scores for the relative contribution of various functional components and the abundance of EPT taxa; the taxonomic composition of the samples was similar in some respects and quite different in others. Some differences are necessarily due to the different seasons during which sampling was carried out. The 1999 sample was collected in September, while the 2001 sample was collected in June. When seasonal differences in functional and taxonomic composition are taken into account, samples appear to produce similar results in terms of water quality and habitat integrity at the Willard site. The functional shift from filter-feeders to gatherers between 1999 and 2001 likely reflects the senescence of aquatic vegetation in the fall rather than any meaningful change in habitat conditions. The doubling of the relative abundance of EPT taxa in the 2001 sample corresponds with the early summer emergence of *Caenis* sp.

The highest biotic index value (7.21) among the sites in the upper reach of O'Fallon Creek was calculated for the assemblage sampled at site AF-3. As at the Willard site, the dominant taxon was the mayfly *Caenis* sp. (27% of the sampled organisms); some other dominants, which also suggest organic and/or nutrient pollution, were the midges *Stichtochironomus* sp., *Paratanytarsus* sp., and *Dicrotendipes* sp. In all, tolerant taxa comprised 64% of the animals in the sample. Sandy substrates are favored by the midges *Pseudochironomus* sp. and *Stichtochironomus* sp., both of which were present in the sample taken here.

Indications of somewhat improved water quality were present further downstream. The biotic index value at site AF-5 was 6.47, suggesting better conditions. The blackfly *Simulium* sp. dominated the assemblage here; this filter-feeder comprised 33% of the organisms sampled. Dominance of *Simulium* sp. is difficult to interpret, since the gregarious nature of the animal may lead to spurious abundances in samples, but plentiful organic particulate material in suspension is suggested.

Instream habitats in these reaches of O'Fallon Creek are apparently fairly diverse. Some clean hard substrate is apparently available, since "clinger" taxa are present at every site. These include *Simulium* sp. (present at all three sites), and the caddis fly *Cheumatopsyche* sp. (present at sites AF-3 and AF-5). Macrophytes apparently add to habitat diversity in these reaches; their presence is suggested by the elmid *Dubiraphia* sp. and the midge *Cricotopus brevipalpus*, both of which are present at all three upper sites on O'Fallon Creek.

Generally lower biotic index values and increased mayfly taxa richness characterize the assemblages collected in the lower reaches of O'Fallon Creek (BF-8 and BF-10). These findings suggest that water quality was less impacted by organic enrichment in these reaches. These sites were the only locations studied that supported scraper taxa, suggesting that water clarity may also have been better here than in the upper reaches.

The number of "clinger" taxa was higher in these lower reaches than in the upper reaches of O'Fallon Creek. Sites in the lower reaches averaged about 6 "clinger" taxa, while lower sites averaged 8 taxa. Caddis fly taxa richness was also generally improved in these reaches, and the abundance of caddis flies was much greater than at the upper sites. At the lowermost site, BF-10, caddis flies comprised 70% of the assemblage. Taxa collected included *Brachycentrus occidentalis* and *Hydropsyche* sp. These findings suggest that hard substrates unaffected by appreciable deposition of fine substrates were more prevalent in lower reaches than in upper reaches.

Bioassessment scores were considerably lower for all sites in the Sandstone Creek drainage than for those on O'Fallon Creek. Tolerant organisms represent significant components of the communities sampled at Sandstone Creek sites. At all sites, the biotic index value was somewhat elevated, but low mayfly richness, and, at two sites, low mayfly abundance suggests that water quality may have been impaired by organic pollution or warm temperatures or both. In addition, low caddis fly taxa richness, coupled with low numbers of "clinger" taxa suggest that fine sediment deposition limited habitats in all sampled reaches of Sandstone Creek.

At the uppermost site, AS-2, the sampled assemblage was overwhelmed by the tolerant midge *Paratanytarsus* sp., which comprised more than 80% of the organisms collected. This midge is associated with fine silty sediments; other indications of fine sediment deposits at this site include the presence of the exquisitely tolerant midge *Chironomus* sp. The few "clinger" taxa present here did not occur abundantly, and macrophytes may have provided habitat for them; the presence of the midge *Cricotopus brevipalpus* suggests the presence of macrophytes. Both midges, as well as most of the other organisms sampled at this site are associated with lentic conditions. The presence of several hemoglobin-bearing midges, including *Chironomus* sp., *Dicrotendipes* sp., *Endochironomus* sp., and *Parachironomus* sp., suggests that sediments at this site are anoxic. This may be due to any combination of lentic conditions, warm water temperatures, and/or nutrient enrichment.

Flow was apparently present at site AS-5, however, since the dominant taxon there was *Simulium* sp., which comprised 67% of the sampled assemblage. Organic particles in suspension were probably abundant to support what appears to be a large number of this filter-feeder. This blackfly is also among the "clinger" taxa and its overwhelming abundance suggests that at least some hard substrates were free of fine sediment deposition. Macrophytes may have substituted as strata for these "clingers" however. Most other taxa present in the sample were highly sediment-tolerant, including the tubificid worm *Limnodrilus hoffmeisteri,* and the mayfly *Caenis latipennis.*

Pseudochironomus sp. appears again at the lowermost site on Sandstone Creek, site CF-11, suggesting that some sandy substrates occurred here instead of the monotonous silt and mud apparently dominating substrates at upstream sites. As at the other sites on this stream, tolerant taxa were the rule; monotonous habitat and degraded water quality appeared to limit diversity.

The bioassessment score calculated for the assemblage at the South Sandstone Creek site (SS-2) was very low. Animals collected at the site were all tolerant taxa and were characteristic of warm water, lentic flow conditions, and soft monotonous substrates. The very high biotic index score (7.66) could be attributed to organic pollution and/or warm temperatures. The dominant taxon was a physid snail, which was probably associated with macrophytes. All other taxa collected were tolerant of fine sediment; very few individuals in benthic taxa were present in the sample.

Among the sites sampled, the uppermost site on Pennel Creek (DF-6) scored the lowest bioassessment rating, with severe impairment of biotic health indicated. Eighty-seven percent of taxa collected at the site were midges, and the dominant taxon was *Tanytarsus* sp., which inhabits soft silty substrates. It is a filter-feeder, and its dominance suggests ample fine organic material in the substrate. *Chironomus* sp., *Dicrotendipes* sp., *Endochironomus* sp., and *Microtendipes* sp. were all present, suggesting anoxic substrates. No mayfly or caddis fly was present in the sample. Lentic conditions are further suggested by the presence of cladoceran taxa, which comprised 8.5% of sampled animals.

Lotic conditions were indicated by the composition of the sample at the lower Pennel Creek site (DF-10). The dominant taxon was *Simulium* sp., which represented 76% of the sampled assemblage. Fine organic material in suspension was apparently plentiful. The next most abundant taxon was the mayfly Caenis latipennis, which suggests fine sediments. Six "clinger" taxa were collected, suggesting that some hard substrates were clear of sediment, although macrophytes may have provided strata for some of these taxa. The biotic index value calculated for the assemblage at this site was the lowest value in the study, suggesting that warm water and/or nutrient enrichment was possibly less a limiting factor at this site than at others.

CONCLUSIONS

- High biotic index values and taxonomic composition of sampled assemblages suggest impairment of water quality by organic and/or nutrient pollution in the upper reaches of O'Fallon Creek (sites at Willard, AF-3, and AF-5).
- Water quality appeared to be less degraded in the lower reaches of O'Fallon Creek, where biotic index values suggested less organic enrichment. Mayfly taxa richness was higher in the lower reaches as well, supporting this thesis.
- There was some evidence that fine sediment deposition was less extensive in the lower reaches of O'Fallon Creek, and that such deposition may have impaired biotic health to some extent in the upper reaches.
- All studied reaches of O'Fallon Creek support long-lived taxa, suggesting that dewatering or other catastrophic events have not recently interrupted life cycles.
- Impairment of biotic health at the uppermost site on Sandstone Creek (AS-2) was apparently attributable to degraded water quality coupled with monotonous, silty or muddy instream habitat and lentic conditions.
- Fine sediment deposition and abundant suspended organic material seem to be indicated by the taxonomic composition of the sample taken at site AS-5 on Sandstone Creek.
- Impairment of biotic health at the lowest site on Sandstone Creek (CF-11) was apparently attributable to degraded water quality coupled with monotonous, sandy instream habitat.

- Lentic conditions, warm water temperatures and/or organic enrichment, and monotonous fine substrates limited potential at the South Sandstone Creek site.
- The upper site on Pennel Creek (DF-6) received the lowest bioassessment score among the sites studied; severe impairment was indicated. Limitations to integrity at the site included lentic conditions, warm water and/or nutrient enrichment, and monotonous habitat.

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APPENDIX

Taxonomic data and summaries

O'Fallon Creek
Pennel Creek
Sandstone and South Sandstone Creeks

June 2001

Aquatic Invertebrate Taxonomic Data

Site Name: O'Fallon Creek at Willard Crossing
Site ID: Willard Crossing

Approx. percent of sample used 67

Taxon	Quantity	Percent	HBI	FFG
Limnodrilus sp.	13	4.38	9	CG
Physidae	3	1.01	8	CG
Gyraulus sp	1	0.34	8	SC
Hyalella azteca	9	3.03	8	CG
Total Misc. Taxa	**26**	**8.75**		
Enallagma sp.	6	2.02	9	PR
Total Odonata	**6**	**2.02**		
Caenis sp.	112	37.71	7	CG
Total Ephemeroptera	**112**	**37.71**		
Corixidae - immature	1	0.34	8	UN
Total Hemiptera	**1**	**0.34**		
Sialis sp.	4	1.35	4	PR
Total Megaloptera	**4**	**1.35**		
Ithytrichia sp	1	0.34	6	SC
Total Trichoptera	**1**	**0.34**		
Dubiraphia sp.	6	2.02	6	CG
Hydrophilidae - larvae	3	1.01	5	PR
Total Coleoptera	**9**	**3.03**		
Ceratopogoninae	1	0.34	6	PR
Simulium sp.	30	10.10	6	CF
Total Diptera	**31**	**10.44**		
Ablabesmyia sp	1	0.34	8	CG
Corynoneura sp.	5	1.68	7	CG
Cricotopus (Isocladius) Gr.	4	1.35	7	CG
Cricotopus brevipalpus	3	1.01	7	CG
Dicrotendipes sp.	14	4.71	8	CG
Parachironomus sp.	3	1.01	10	PR
Paratanytarsus sp.	72	24.24	6	UN
Pseudochironomus sp.	2	0.67	5	CG
Tanytarsus sp.	3	1.01	6	CF
Total Chironomidae	**107**	**36.03**		
Grand Total	**297**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: O'Fallon Creek at Willard Crossing

Site ID: Willard Crossing

TOTAL ABUNDANCE	297
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	113
TOTAL NUMBER OF TAXA	22
Number EPT taxa	2

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	4	26	8.75
Odonata	1	6	2.02
Ephemeroptera	1	112	37.71
Plecoptera	0	0	0.00
Hemiptera	1	1	0.34
Megaloptera	1	4	1.35
Trichoptera	1	1	0.34
Lepidoptera	0	0	0.00
Coleoptera	2	9	3.03
Diptera	2	31	10.44
Chironomidae	9	107	36.03

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	1.06

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	5	17	5.72
Parasite	0	0	0.00
Collector-gatherer	11	172	57.91
Collector-filterer	2	33	11.11
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	2	2	0.67
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	0	0	0.00
Unknown	2	73	24.58

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.06
Scraper/(Scraper + C.filterer)	0.06
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Caenis sp.	112	37.71
Paratanytarsus sp	72	24.24
Simulium sp.	30	10.10
Dicrotendipes sp.	14	4.71
Limnodrilus sp.	13	4.38
SUBTOTAL 5 DOMINANTS	241	81.14
Hyalella azteca	9	3.03
Enallagma sp.	6	2.02
Dubiraphia sp.	6	2.02
Corynoneura sp.	5	1.68
Sialis sp.	4	1.35
TOTAL DOMINANTS	271	91.25

SAPROBIC INDICES

Hilsenhoff Biotic Index	6.80

DIVERSITY MEASURES

Shannon H (loge)	1.66
Shannon H (log2)	2.39
Evenness	0.54
Simpson D	0.17

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	81	27.27
Univoltine	207	69.70
Semivoltine	9	3.03

	#TAXA	ABUNDANCE	PERCENT
Tolerant	7	149	50.17
Intolerant	0	0	0.00
Clinger	5	47	15.82

Aquatic Invertebrate Taxonomic Data

Site Name: O'Fallon Creek

Site ID: AF-3

Approx. percent of sample used: 47

Taxon	**Quantity**	**Percent**	**HBI**	**FFG**
Nais variabilis	5	1.68	8	CG
Physidae	6	2.02	8	CG
Hyalella azteca	1	0.34	8	CG
Acari	10	3.37	5	PA
Total Misc. Taxa	**22**	**7.41**		
Enallagma sp.	3	1.01	9	PR
Total Odonata	**3**	**1.01**		
Caenis sp.	79	26.60	7	CG
Total Ephemeroptera	**79**	**26.60**		
Cheumatopsyche sp.	10	3.37	8	CF
Hydropsyche sp.	1	0.34	4	CF
Hydroptila sp	1	0.34	6	PH
Ithytrichia sp.	2	0.67	6	SC
Total Trichoptera	**14**	**4.71**		
Dubiraphia sp.	2	0.67	6	CG
Total Coleoptera	**2**	**0.67**		
Ceratopogoninae	1	0.34	6	PR
Simulium sp.	23	7.74	6	CF
Total Diptera	**24**	**8.08**		
Cricotopus (Isocladius) Gr	13	4.38	7	CG
Cryptochironomus sp.	2	0.67	8	PR
Cryptotendipes sp.	2	0.67	6	UN
Dicrotendipes sp.	30	10.10	8	CG
Paratanytarsus sp.	46	15.49	6	UN
Pseudochironomus sp	2	0.67	5	CG
Stictochironomus sp	55	18.52	9	CG
Thienemannimyia Gr.	3	1.01	6	PR
Total Chironomidae	**153**	**51.52**		
Grand Total	**297**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: O'Fallon Creek | **Site ID: AF-3**

TOTAL ABUNDANCE	297
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	93
TOTAL NUMBER OF TAXA	21
Number EPT taxa	5

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	4	22	7.41
Odonata	1	3	1.01
Ephemeroptera	1	79	26.60
Plecoptera	0	0	0.00
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	4	14	4.71
Lepidoptera	0	0	0.00
Coleoptera	1	2	0.67
Diptera	2	24	8.08
Chironomidae	8	153	51.52

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.61

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	4	9	3.03
Parasite	1	10	3.37
Collector-gatherer	9	193	64.98
Collector-filterer	3	34	11.45
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	1	1	0.34
Scraper	1	2	0.67
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	0	0	0.00
Unknown	2	48	16.16

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.06
Scraper/(Scraper + C.filterer)	0.06
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Caenis sp.	79	26.60
Stictochironomus sp	55	18.52
Paratanytorsus sp.	46	15.49
Dicrotendipes sp.	30	10.10
Simulium sp.	23	7.74
SUBTOTAL 5 DOMINANTS	233	78.45
Cricotopus (Isocladius) Gr.	13	4.38
Acari	10	3.37
Cheumatopsyche sp.	10	3.37
Physidae	6	2.02
Nais variabilis	5	1.68
TOTAL DOMINANTS	277	93.26

SAPROBIC INDICES

Hilsenhoff Biotic Index	7.21

DIVERSITY MEASURES

Shannon H (loge)	1.88
Shannon H (log2)	2.71
Evenness	0.62
Simpson D	0.13

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	130	43.69
Univoltine	165	55.64
Semivoltine	2	0.67

	#TAXA	ABUNDANCE	PERCENT
Tolerant	11	190	63.97
Intolerant	0	0	0.00
Clinger	7	52	17.51

Aquatic Invertebrate Taxonomic Data

Site Name: O'Fallon Creek
Site ID: AF-5

Approx. percent of sample used: 100

Taxon	Quantity	Percent	HBI	FFG
Acari	24	8.96	5	PA
Total Misc. Taxa	**24**	**8.96**		
Enallagma sp.	11	4.10	9	PR
Total Odonata	**11**	**4.10**		
Caenis sp.	56	20.90	7	CG
Total Ephemeroptera	**56**	**20.90**		
Sigara sp.	1	0.37	8	PH
Ambrysus sp.	1	0.37	11	PR
Total Hemiptera	**2**	**0.75**		
Sialis sp.	1	0.37	4	PR
Total Megaloptera	**1**	**0.37**		
Cheumatopsyche sp.	4	1.49	8	CF
Total Trichoptera	**4**	**1.49**		
Dubiraphia sp.	2	0.75	6	CG
Hydrophilidae - larvae	1	0.37	5	PR
Total Coleoptera	**3**	**1.12**		
Ceratopogoninae	11	4.10	6	PR
Simulium sp.	88	32.84	6	CF
Total Diptera	**99**	**36.94**		
Cricotopus (Isocladius) Gr.	14	5.22	7	CG
Cricotopus brevipalpus	2	0.75	7	CG
Dicrotendipes sp.	19	7.09	8	CG
Endochironomus sp.	1	0.37	10	CG
Paratanytarsus sp.	11	4.10	6	UN
Polypedilum sp.	1	0.37	6	OM
Pseudochironomus sp.	8	2.99	5	CG
Tanytarsus sp.	9	3.36	6	CF
Thienemannimyia Gr.	3	1.12	6	PR
Total Chironomidae	**68**	**25.37**		
Grand Total	**268**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: O'Fallon Creek

Site ID: AF-5

TOTAL ABUNDANCE	268
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	60
TOTAL NUMBER OF TAXA	20
Number EPT taxa	2

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	1	24	8.96
Odonata	1	11	4.10
Ephemeroptera	1	56	20.90
Plecoptera	0	0	0.00
Hemiptera	2	2	0.75
Megaloptera	1	1	0.37
Trichoptera	1	4	1.49
Lepidoptera	0	0	0.00
Coleoptera	2	3	1.12
Diptera	2	99	36.94
Chironomidae	9	68	25.37

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.88

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	6	28	10.45
Parasite	1	24	8.96
Collector-gatherer	7	102	38.06
Collector-filterer	3	101	37.69
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	1	1	0.37
Scraper	0	0	0.00
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	1	1	0.37
Unknown	1	11	4.10

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.00
Scraper/(Scraper + C.filterer)	0.00
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Simulium sp.	88	32.84
Caenis sp.	56	20.90
Acari	24	8.96
Dicrotendipes sp.	19	7.09
Cricotopus (Isocladius) Gr	14	5.22
SUBTOTAL 5 DOMINANTS	201	75.00
Enallagma sp.	11	4.10
Ceratopogoninae	11	4.10
Paratanytarsus sp.	11	4.10
Tanytarsus sp.	9	3.36
Pseudochironomus sp.	8	2.99
TOTAL DOMINANTS	251	93.65

SAPROBIC INDICES

Hilsenhoff Biotic Index	6.47

DIVERSITY MEASURES

Shannon H (loge)	1.80
Shannon H (log2)	2.59
Evenness	0.60
Simpson D	0.14

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	76	28.36
Univoltine	189	70.52
Semivoltine	3	1.12

	#TAXA	ABUNDANCE	PERCENT
Tolerant	5	82	30.60
Intolerant	0	0	0.00
Clinger	7	120	44.78

Aquatic Invertebrate Taxonomic Data

Site Name: O'Fallon Creek

Site ID: BF-8

Approx. percent of sample used 40

Taxon	Quantity	Percent	HBI	FFG
Nais variabilis	17	5.38	8	CG
Physidae	1	0.32	8	CG
Hyalella azteca	4	1.27	8	CG
Acari	1	0.32	5	PA
Total Misc. Taxa	**23**	**7.28**		
Callibaetis sp.	1	0.32	9	CG
Fallceon quilleri	3	0.95	4	CG
Caenis sp.	4	1.27	7	CG
Leucrocuta sp.	4	1.27	2	SC
Choroterpes sp.	1	0.32	7	CG
Isonychia sp.	2	0.63	2	CF
Total Ephemeroptera	**15**	**4.75**		
Ambrysus sp.	7	2.22	11	PR
Total Hemiptera	**7**	**2.22**		
Sialis sp.	2	0.63	4	PR
Total Megaloptera	**2**	**0.63**		
Cheumatopsyche sp.	79	25.00	8	CF
Hydropsyche sp.	24	7.59	4	CF
Ithytrichia sp.	36	11.39	6	SC
Total Trichoptera	**139**	**43.99**		
Dubiraphia sp	5	1.58	6	CG
Tropisternus sp.	1	0.32	5	PR
Total Coleoptera	**6**	**1.90**		
Ceratopogoninae	1	0.32	6	PR
Simulium sp.	25	7.91	6	CF
Total Diptera	**26**	**8.23**		
Cladotanytarsus sp.	1	0.32	7	CG
Cricotopus (Isocladius) Gr.	62	19.62	7	CG
Dicrotendipes sp.	2	0.63	8	CG
Labrundinia sp.	1	0.32	7	PR
Paratanytarsus sp.	18	5.70	6	UN
Pseudochironomus sp.	4	1.27	5	CG
Tanytarsus sp.	7	2.22	6	CF
Thienemannimyia Gr.	3	0.95	6	PR
Total Chironomidae	**98**	**31.01**		
Grand Total	**316**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: O'Fallon Creek

Site ID: BF-8

TOTAL ABUNDANCE	316
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	154
TOTAL NUMBER OF TAXA	27
Number EPT taxa	9

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	4	23	7.28
Odonata	0	0	0.00
Ephemeroptera	6	15	4.75
Plecoptera	0	0	0.00
Hemiptera	1	7	2.22
Megaloptera	1	2	0.63
Trichoptera	3	139	43.99
Lepidoptera	0	0	0.00
Coleoptera	2	6	1.90
Diptera	2	26	8.23
Chironomidae	8	98	31.01

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	1.57

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	6	15	4.75
Parasite	1	1	0.32
Collector-gatherer	12	105	33.23
Collector-filterer	5	137	43.35
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	2	40	12.66
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	0	0	0.00
Unknown	1	18	5.70

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.29
Scraper/(Scraper + C.filterer)	0.23
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Cheumatopsyche sp	79	25.00
Cricotopus (Isocladius) Gr	62	19.62
Ithytrichia sp.	36	11.39
Simulium sp.	25	7.91
Hydropsyche sp.	24	7.59
SUBTOTAL 5 DOMINANTS	226	71.52
Paratanytarsus sp.	18	5.70
Nais variabilis	17	5.38
Ambrysus sp.	7	2.22
Tanytarsus sp.	7	2.22
Dubiraphia sp	5	1.58
TOTAL DOMINANTS	280	88.61

SAPROBIC INDICES

Hilsenhoff Biotic Index	6.71

DIVERSITY MEASURES

Shannon H (loge)	2.05
Shannon H (log2)	2.96
Evenness	0.62
Simpson D	0.11

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	130	41.22
Univoltine	180	56.88
Semivoltine	6	1.90

	#TAXA	ABUNDANCE	PERCENT
Tolerant	9	134	42.41
Intolerant	0	0	0.00
Clinger	8	242	76.58

Aquatic Invertebrate Taxonomic Data

Site Name: O'Fallon Creek
Site ID: BF-16

Approx. percent of sample used 27

Taxon	**Quantity**	**Percent**	**HBI**	**FFG**
Turbellaria	1	0.31	4	CG
Limnodrilus sp.	19	5.96	9	CG
Aulodrilus pigueti	5	1.57	9	CG
Lampsilis sp.	1	0.31	6	CF
Physidae	17	5.33	8	CG
Hyalella azteca	11	3.45	8	CG
Acari	1	0.31	5	PA
Total Misc. Taxa	**55**	**17.24**		
Caenis sp.	1	0.31	7	CG
Leucrocuta sp.	1	0.31	2	SC
Isonychia sp.	4	1.25	2	CF
Total Ephemeroptera	**6**	**1.88**		
Corixidae - immature	1	0.31	8	UN
Sigara sp.	1	0.31	8	PH
Ambrysus sp.	3	0.94	11	PR
Total Hemiptera	**5**	**1.57**		
Sialis sp.	1	0.31	4	PR
Total Megaloptera	**1**	**0.31**		
Brachycentrus occidentalis	9	2.82	1	OM
Cheumatopsyche sp.	88	27.59	8	CF
Hydropsyche sp.	60	18.81	4	CF
Hydroptila sp.	51	15.99	6	PH
Ithytrichia sp.	14	4.39	6	SC
Total Trichoptera	**222**	**69.59**		
Helichus sp.	1	0.31	5	SH
Dubiraphia sp.	2	0.63	6	CG
Total Coleoptera	**3**	**0.94**		
Simulium sp.	4	1.25	6	CF
Total Diptera	**4**	**1.25**		
Endochironomus sp.	1	0.31	10	CG
Paratanytarsus sp.	12	3.76	6	UN
Polypedilum sp.	8	2.51	6	OM
Tanytarsus sp.	1	0.31	6	CF
Thienemannimyia Gr.	1	0.31	6	PR
Total Chironomidae	**23**	**7.21**		
Grand Total	**319**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: O'Fallon Creek

Site ID: BF-16

TOTAL ABUNDANCE	319
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	228
TOTAL NUMBER OF TAXA	27
Number EPT taxa	8

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	7	55	17.24
Odonata	0	0	0.00
Ephemeroptera	3	6	1.88
Plecoptera	0	0	0.00
Hemiptera	3	5	1.57
Megaloptera	1	1	0.31
Trichoptera	5	222	69.59
Lepidoptera	0	0	0.00
Coleoptera	2	3	0.94
Diptera	1	4	1.25
Chironomidae	5	23	7.21

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	9.91

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	3	5	1.57
Parasite	1	1	0.31
Collector-gatherer	8	57	17.87
Collector-filterer	6	158	49.53
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	2	52	16.30
Scraper	2	15	4.70
Shredder	1	1	0.31
Xylophage	0	0	0.00
Omnivore	2	17	5.33
Unknown	2	13	4.08

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.09
Scraper/(Scraper + C.filterer)	0.09
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Cheumatopsyche sp	88	27.59
Hydropsyche sp	60	18.81
Hydroptila sp.	51	15.99
Limnodrilus sp.	19	5.96
Physidae	17	5.33
SUB-TOTAL 5 DOMINANTS	235	27.59
Ithytrichia sp.	14	4.39
Paratanytarsus sp.	12	3.76
Hyalella azteca	11	3.45
Brachycentrus occidentalis	9	2.82
Polypedilum sp.	8	2.51
TOTAL DOMINANTS	289	44.52

SAPROBIC INDICES

Hilsenhoff Biotic Index	6.43

DIVERSITY MEASURES

Shannon H (loge)	1.96
Shannon H (log2)	2.83
Evenness	0.60
Simpson D	0.13

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	105	32.92
Univoltine	201	63.01
Semivoltine	13	4.08

	#TAXA	ABUNDANCE	PERCENT
Tolerant	8	186	58.31
Intolerant	0	0	0.00
Clinger	10	238	74.61

Aquatic Invertebrate Taxonomic Data

Site Name: Sandstone Creek, Leibee Bridge
Site ID: AS-2

Approx. percent of sample used: 87

Taxon	**Quantity**	**Percent**	**HBI**	**FFG**
Nais variabilis	1	0.32	8	CG
Limnodrilus sp.	1	0.32	9	CG
Physidae	12	3.86	8	CG
Hyalella azteca	3	0.96	8	CG
Total Misc. Taxa	**17**	**5.47**		
Gomphus sp.	1	0.32	5	PR
Enallagma sp.	1	0.32	9	PR
Total Odonata	**2**	**0.64**		
Callibaetis sp.	1	0.32	9	CG
Caenis sp.	2	0.64	7	CG
Total Ephemeroptera	**3**	**0.96**		
Ithytrichia sp.	1	0.32	6	SC
Total Trichoptera	**1**	**0.32**		
Dubiraphia sp	14	4.50	6	CG
Total Coleoptera	**14**	**4.50**		
Ceratopogoninae	2	0.64	6	PR
Total Diptera	**2**	**0.64**		
Chironomus sp.	2	0.64	10	CG
Cricotopus Bicinctus Gr	1	0.32	7	CG
Cricotopus (Isocladius) Gr	5	1.61	7	CG
Cricotopus brevipalpus	2	0.64	7	CG
Dicrotendipes sp	7	2.25	8	CG
Endochironomus sp	1	0.32	10	CG
Parachironomus sp	1	0.32	10	PR
Paratanytarsus sp.	251	80.71	6	UN
Polypedilum sp	2	0.64	6	OM
Total Chironomidae	**272**	**87.46**		
Grand Total	**311**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: Sandstone Creek, Leibee Bridge

Site ID: AS-2

TOTAL ABUNDANCE	311
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	4
TOTAL NUMBER OF TAXA	20
Number EPT taxa	3

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	4	17	5.47
Odonata	2	2	0.64
Ephemeroptera	2	3	0.96
Plecoptera	0	0	0.00
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	1	1	0.32
Lepidoptera	0	0	0.00
Coleoptera	1	14	4.50
Diptera	1	2	0.64
Chironomidae	9	272	87.46

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.01

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	4	5	1.61
Parasite	0	0	0.00
Collector-gatherer	13	52	16.72
Collector-filterer	0	0	0.00
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	1	1	0.32
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	1	2	0.64
Unknown	1	251	80.71

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	#DIV/0!
Scraper/(Scraper + C.filterer)	1.00
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Paratanytarsus sp	251	80.71
Dubiraphia sp.	14	4.50
Physidae	12	3.86
Dicrotendipes sp.	7	2.25
Cricotopus (Isocladius) Gr.	5	1.61
SUBTOTAL 5 DOMINANTS	289	92.93
Hyalella azteca	3	0.96
Caenis sp.	2	0.64
Ceratopogoninae	2	0.64
Chironomus sp.	2	0.64
Cricotopus brevipalpus	2	0.64
TOTAL DOMINANTS	300	96.46

SAPROBIC INDICES

Hilsenhoff Biotic Index	6.26

DIVERSITY MEASURES

Shannon H (loge)	0.60
Shannon H (log2)	0.87
Evenness	0.20
Simpson D	0.52

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	206	66.08
Univoltine	91	29.10
Semivoltine	15	4.82

	#TAXA	ABUNDANCE	PERCENT
Tolerant	8	44	14.15
Intolerant	0	0	0.00
Clinger	6	25	8.04

Aquatic Invertebrate Taxonomic Data

Site Name: Sandstone Creek

Site ID: AS-5

Approx. percent of sample used 47

Taxon	**Quantity**	**Percent**	**HBI**	**FFG**
Nais variabilis	4	1.27	8	CG
Limnodrilus hoffmeisteri	9	2.86	9	CG
Ferrissia sp	1	0.32	6	SC
Physidae	1	0.32	8	CG
Hyalella azteca	1	0.32	8	CG
Acari	3	0.95	5	PA
Total Misc. Taxa	**19**	**6.03**		
Enallagma sp.	1	0.32	9	PR
Total Odonata	**1**	**0.32**		
Caenis sp.	19	6.03	7	CG
Total Ephemeroptera	**19**	**6.03**		
Dubiraphia sp.	2	0.63	6	CG
Total Coleoptera	**2**	**0.63**		
Ceratopogoninae	3	0.95	6	PR
Simulium sp.	210	66.67	6	CF
Total Diptera	**213**	**67.62**		
Ablabesmyia sp.	1	0.32	8	CG
Chironomus sp.	2	0.63	10	CG
Cricotopus (Isocladius) Gr.	24	7.62	7	CG
Cryptochironomus sp	1	0.32	8	PR
Dicrotendipes sp.	25	7.94	8	CG
Endochironomus sp.	6	1.90	10	CG
Paratanytarsus sp.	1	0.32	6	UN
Thienemanniella sp.	1	0.32	6	CG
Total Chironomidae	**61**	**19.37**		
Grand Total	**315**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: Sandstone Creek

Site ID: AS-5

TOTAL ABUNDANCE	315
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	19
TOTAL NUMBER OF TAXA	19
Number EPT taxa	1

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	6	19	6.03
Odonata	1	1	0.32
Ephemeroptera	1	19	6.03
Plecoptera	0	0	0.00
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	0	0	0.00
Lepidoptera	0	0	0.00
Coleoptera	1	2	0.63
Diptera	2	213	67.62
Chironomidae	8	61	19.37

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.31

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	3	5	1.59
Parasite	1	3	0.95
Collector-gatherer	12	95	30.16
Collector-filterer	1	210	66.67
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	1	1	0.32
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	0	0	0.00
Unknown	1	1	0.32

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.00
Scraper/(Scraper + C.filterer)	0.00
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Simulium sp.	210	66.67
Dicrotendipes sp.	25	7.94
Cricotopus (Isocladius) Gr	24	7.62
Caenis sp.	19	6.03
Limnodrilus hoffmeisteri	9	2.86
SUB-TOTAL 5 DOMINANTS	287	91.11
Endochironomus sp.	6	1.90
Nais variabilis	4	1.27
Acari	3	0.95
Ceratopogoninae	3	0.95
Dubiraphia sp.	2	0.63
TOTAL DOMINANTS	18	5.71

SAPROBIC INDICES

Hilsenhoff Biotic Index	6.53

DIVERSITY MEASURES

Shannon H (loge)	1.37
Shannon H (log2)	1.97
Evenness	0.46
Simpson D	0.46

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	49	15.48
Univoltine	264	83.89
Semivoltine	2	0.63

	#TAXA	ABUNDANCE	PERCENT
Tolerant	9	58	18.41
Intolerant	0	0	0.00
Clinger	3	236	74.92

Aquatic Invertebrate Taxonomic Data

Site Name: Sandstone Creek, Bill Bickle bridge near state section

Site ID: CF-11

Approx. percent of sample used. 23

Taxon	**Quantity**	**Percent**	**HBI**	**FFG**
Nematoda	1	0.32	5	PA
Nais variabilis	4	1.29	8	CG
Limnodrilus sp.	4	1.29	9	CG
Hyalella azteca	3	0.97	8	CG
Total Misc. Taxa	**12**	**3.88**		
Enallagma sp.	4	1.29	9	PR
Total Odonata	**4**	**1.29**		
Caenis sp.	83	26.86	7	CG
Total Ephemeroptera	**83**	**26.86**		
Hydropsyche sp.	1	0.32	4	CF
Total Trichoptera	**1**	**0.32**		
Dubiraphia sp.	5	1.62	6	CG
Total Coleoptera	**5**	**1.62**		
Ceratopogoninae	10	3.24	6	PR
Simulium sp.	38	12.30	6	CF
Stratiomys sp.	1	0.32	8	CG
Total Diptera	**49**	**15.86**		
Cricotopus (Isocladius) Gr.	111	35.92	7	CG
Cryptochironomus sp.	1	0.32	8	PR
Dicrotendipes sp.	2	0.65	8	CG
Pseudochironomus sp.	12	3.88	5	CG
Tanytarsus sp.	27	8.74	6	CF
Thienemannimyia Gr.	2	0.65	6	PR
Total Chironomidae	**155**	**50.16**		
Grand Total	**309**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: Sandstone Creek, Bill Bickle bridge near state section **Site ID: CF-11**

TOTAL ABUNDANCE	309
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	84
TOTAL NUMBER OF TAXA	17
Number EPT taxa	2

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	4	12	3.88
Odonata	1	4	1.29
Ephemeroptera	1	83	26.86
Plecoptera	0	0	0.00
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	1	1	0.32
Lepidoptera	0	0	0.00
Coleoptera	1	5	1.62
Diptera	3	49	15.86
Chironomidae	6	155	50.16

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.54

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	4	17	5.50
Parasite	1	1	0.32
Collector-gatherer	9	225	72.82
Collector-filterer	3	66	21.36
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	0	0	0.00
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	0	0	0.00
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.00
Scraper/(Scraper + C.filterer)	0.00
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Cricotopus (Isocladius) Gr	111	35.92
Caenis sp.	83	26.86
Simulium sp.	38	12.30
Tanytarsus sp.	27	8.74
Pseudochironomus sp.	12	3.88
SUBTOTAL 5 DOMINANTS	271	87.70
Ceratopogoninae	10	3.24
Dubiraphia sp.	5	1.62
Nais variabilis	4	1.29
Limnodrilus sp.	4	1.29
Hyallela azteca	3	0.97
TOTAL DOMINANTS	297	96.11

SAPROBIC INDICES

Hilsenhoff Biotic Index	6.73

DIVERSITY MEASURES

Shannon H (loge)	1.49
Shannon H (log2)	2.15
Evenness	0.53
Simpson D	0.19

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	118	38.03
Univoltine	187	60.36
Semivoltine	5	1.62

	#TAXA	ABUNDANCE	PERCENT
Tolerant	6	95	30.74
Intolerant	0	0	0.00
Clinger	5	182	58.90

Aquatic Invertebrate Taxonomic Data

Site Name: South Sandstone Creek, about 1000 ft. from mouth. South of Plevna.

Site ID: SS-3 Approx. percent of sample used 100

Taxon	**Quantity**	**Percent**	**HBI**	**FFG**
Limnodrilus sp.	3	1.12	9	CG
Fossaria sp.	18	6.74	6	CG
Physidae	177	66.29	8	CG
Gyraulus sp.	3	1.12	8	SC
Cladocera	1	0.37	8	CF
Hyalella azteca	8	3.00	8	CG
Total Misc. Taxa	**210**	**78.65**		
Libellula sp.	2	0.75	9	PR
Enallagma sp.	5	1.87	9	PR
Lestes sp.	11	4.12	9	PR
Total Odonata	**18**	**6.74**		
Callibaetis sp.	1	0.37	9	CG
Total Ephemeroptera	**1**	**0.37**		
Hydropsyche sp.	1	0.37	4	CF
Total Trichoptera	**1**	**0.37**		
Hygrotus sp.	1	0.37	5	PR
Dubiraphia sp.	28	10.49	6	CG
Haliplus sp.	3	1.12	5	MH
Berosus sp.	1	0.37	5	PR
Total Coleoptera	**33**	**12.36**		
Culiseta sp.	1	0.37	8	CG
Total Diptera	**1**	**0.37**		
Cricotopus (Isocladius) Gr	1	0.37	7	CG
Dicrotendipes sp.	2	0.75	8	CG
Total Chironomidae	**3**	**1.12**		
Grand Total	267	100.00		

Aquatic Invertebrate Summary Data

Site Name: South Sandstone Creek, about 1000 ft. from mouth. South of Plevna. **Site ID: SS-3**

TOTAL ABUNDANCE	267
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	2
TOTAL NUMBER OF TAXA	18
Number EPT taxa	2

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	6	210	78.65
Odonata	3	18	6.74
Ephemeroptera	1	1	0.37
Plecoptera	0	0	0.00
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	1	1	0.37
Lepidoptera	0	0	0.00
Coleoptera	4	33	12.36
Diptera	1	1	0.37
Chironomidae	2	3	1.12

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.67

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	5	20	7.49
Parasite	0	0	0.00
Collector-gatherer	9	239	89.51
Collector-filterer	2	2	0.75
Macrophyte-herbivore	1	3	1.12
Piercer-herbivore	0	0	0.00
Scraper	1	3	1.12
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	0	0	0.00
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	1.50
Scraper/(Scraper + C.filterer)	0.60
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Physidae	177	66.29
Dubiraphia sp	28	10.49
Fossaria sp.	18	6.74
Lestes sp	11	4.12
Hyalella azteca	8	3.00
SUB-TOTAL 5 DOMINANTS	242	90.64
Enallagma sp.	5	1.87
Limnodrilus sp.	3	1.12
Gyraulus sp.	3	1.12
Haliplus sp.	3	1.12
Libellula sp.	2	0.75
TOTAL DOMINANTS	16	5.99

SAPROBIC INDICES

Hilsenhoff Biotic Index	7.66

DIVERSITY MEASURES

Shannon H (loge)	1.01
Shannon H (log2)	1.46
Evenness	0.35
Simpson D	0.36

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	4	1.59
Univoltine	228	85.30
Semivoltine	35	13.11

	#TAXA	ABUNDANCE	PERCENT
Tolerant	9	243	91.01
Intolerant	0	0	0.00
Clinger	3	30	11.24

Aquatic Invertebrate Taxonomic Data

Site Name: Pennel Creek

Site ID: DF-6

Approx. percent of sample used: 7

Taxon	**Quantity**	**Percent**	**HBI**	**FFG**
Enchytraeidae	1	0.33	4	CG
Nais sp.	1	0.33	8	CG
Physidae	5	1.63	8	CG
Cladocera	26	8.50	8	CF
Acari	1	0.33	5	PA
Total Misc. Taxa	**34**	**11.11**		
Dytiscidae	6	1.96	5	PR
Berosus sp.	1	0.33	5	PR
Total Coleoptera	**7**	**2.29**		
Ablabesmyia sp.	1	0.33	8	CG
Chironomus sp.	1	0.33	10	CG
Corynoneura sp.	4	1.31	7	CG
Cricotopus sp.	28	9.15	7	CG
Dicrotendipes sp.	2	0.65	8	CG
Endochironomus sp.	3	0.98	10	CG
Microtendipes sp.	73	23.86	6	CG
Tanytarsus sp.	153	50.00	6	CF
Total Chironomidae	**265**	**86.60**		
Grand Total	**306**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: Pennel Creek

Site ID: DF-6

TOTAL ABUNDANCE	306
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	0
TOTAL NUMBER OF TAXA	15
Number EPT taxa	0

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	5	34	11.11
Odonata	0	0	0.00
Ephemeroptera	0	0	0.00
Plecoptera	0	0	0.00
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	0	0	0.00
Lepidoptera	0	0	0.00
Coleoptera	2	7	2.29
Diptera	0	0	0.00
Chironomidae	8	265	86.60

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.00

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	2	7	2.29
Parasite	1	1	0.33
Collector-gatherer	10	119	38.89
Collector-filterer	2	179	58.50
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	0	0	0.00
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	0	0	0.00
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.00
Scraper/(Scraper + C.filterer)	0.00
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Tanytarsus sp.	153	50.00
Microtendipes sp	73	23.86
Cricotopus sp	28	9.15
Cladocera	26	8.50
Dytiscidae	6	1.96
SUBTOTAL 5 DOMINANTS	286	93.46
Physidae	5	1.63
Corynoneura sp.	4	1.31
Endochironomus sp.	3	0.98
Dicrotendipes sp.	2	0.65
Enchytraeidae	1	0.33
TOTAL DOMINANTS	301	98.37

SAPROBIC INDICES

Hilsenhoff Biotic Index	6.35

DIVERSITY MEASURES

Shannon H (loge)	1.51
Shannon H (log2)	2.18
Evenness	0.56
Simpson D	#DIV/0!

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	226	73.77
Univoltine	73	23.94
Semivoltine	7	2.29

	#TAXA	ABUNDANCE	PERCENT
Tolerant	6	18	5.88
Intolerant	0	0	0.00
Clinger	2	181	59.15

Aquatic Invertebrate Taxonomic Data

Site Name: Pennel Creek
Site ID: DF-10

Approx. percent of sample used: 13

Taxon	**Quantity**	**Percent**	**HBI**	**FFG**
Physidae	4	1.21	8	CG
Hyalella azteca	2	0.61	8	CG
Total Misc. Taxa	**6**	**1.82**		
Caenis sp.	17	5.15	7	CG
Total Ephemeroptera	**17**	**5.15**		
Corixidae - immature	1	0.30	8	UN
Total Hemiptera	**1**	**0.30**		
Hydropsyche sp.	1	0.30	4	CF
Hydroptila sp.	1	0.30	6	PH
Total Trichoptera	**2**	**0.61**		
Peltodytes sp.	2	0.61	5	MH
Hydrophilidae - larvae	3	0.91	5	PR
Total Coleoptera	**5**	**1.52**		
Hemerodromia sp.	1	0.30	6	PR
Simulium sp.	249	75.45	6	CF
Total Diptera	**250**	**75.76**		
Ablabesmyia sp.	1	0.30	8	CG
Cricotopus sp	15	4.55	7	CG
Dicrotendipes sp.	7	2.12	8	CG
Paratanytarsus sp.	13	3.94	6	UN
Polypedilum sp	1	0.30	6	OM
Tanytarsus sp	8	2.42	6	CF
Thienemannimyia Gr.	4	1.21	6	PR
Total Chironomidae	**49**	**14.85**		
Grand Total	**330**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: Pennel Creek

Site ID: DF-10

TOTAL ABUNDANCE	330
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	19
TOTAL NUMBER OF TAXA	17
Number EPT taxa	3

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	2	6	1.82
Odonata	0	0	0.00
Ephemeroptera	1	17	5.15
Plecoptera	0	0	0.00
Hemiptera	1	1	0.30
Megaloptera	0	0	0.00
Trichoptera	2	2	0.61
Lepidoptera	0	0	0.00
Coleoptera	2	5	1.52
Diptera	2	250	75.76
Chironomidae	7	49	14.85

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.39

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	3	8	2.42
Parasite	0	0	0.00
Collector-gatherer	6	46	13.94
Collector-filterer	3	258	78.18
Macrophyte-herbivore	1	2	0.61
Piercer-herbivore	1	1	0.30
Scraper	0	0	0.00
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	1	1	0.30
Unknown	2	14	4.24

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.00
Scraper/(Scraper + C.filterer)	0.00
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Simulium sp.	249	75.45
Caenis sp.	17	5.15
Cricotopus sp.	15	4.55
Paratanytarsus sp.	13	3.94
Tanytarsus sp.	8	2.42
SUBTOTAL 5 DOMINANTS	302	91.52
Dicrotendipes sp.	7	2.12
Physidae	4	1.21
Theienemannimyia Gr.	4	1.21
Hydrophilidae	3	0.91
Hyallela azteca	2	0.61
TOTAL DOMINANTS	322	97.58

SAPROBIC INDICES

Hilsenhoff Biotic Index	6.17

DIVERSITY MEASURES

Shannon H (loge)	0.76
Shannon H (log2)	1.10
Evenness	0.27
Simpson D	0.46

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	38	11.44
Univoltine	287	87.05
Semivoltine	5	1.52

	#TAXA	ABUNDANCE	PERCENT
Tolerant	7	34	10.30
Intolerant	0	0	0.00
Clinger	6	275	83.33

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BIOASSESSMENT OF THE REDWATER RIVER

McCONE AND DAWSON COUNTIES, MONTANA

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August, 1999. Revised September, 1999.

INTRODUCTION

Benthic assemblages are aptly applied to aquatic bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970.) Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations. Multimetric approaches to bioassessment use attributes of the assemblage in an integrated way to measure overall biotic condition.

The additive multimetric approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "… an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment. (Fore et al. 1995). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998). The first element is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied must be done, to assist in the interpretation of metric outcomes.

This report summarizes data collected in May 1999 from the Redwater River and the East Fork of the Redwater River; a multimetric method is used. This method is an adaptation of the U.S. EPA's Rapid Bioassessment Protocols (RBP III) (Plafkin et al. 1989). Macroinvertebrates were collected at ten sites, encompassing a great deal of the length of the river. The Redwater and its East Fork lie entirely within the Plains ecoregions of Montana.

Metric selection for this study was based on the recommendations found in the standard operating procedures for macroinvertebrate sampling and analysis of the Montana Department of Environmental Quality (MT DEQ) (Bukantis 1998). Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat parameters and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Assurance of the validity of association between habitat parameters and biotic metrics is particularly compelling in the Plains ecoregions, since impairment of the biotic health of rivers in these regions is generally the result of non-point sources. Agricultural activities, including cattle grazing and flow alteration, are predominant causes of stream degradation. The benthic assemblages of the Plains ecoregions and the performance of bioassessment metrics have not yet been examined thoroughly enough to determine whether or not the individual metrics or their integrated scores can discriminate impaired conditions from good biotic health. Bollman (1998) has recently studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics specific to that ecoregion, which has been shown to be sensitive to impairment, related to habitat assessment parameters and consistent over replicated samples. No such study has yet been undertaken for the Plains ecoregions.

Habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by salinity or toxicants, or high levels of organic and/or nutrient pollution might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment in an oligotrophic setting. Habitat assessment data is even more important in the Plains ecoregions, where the relationships between habitat variables and benthic community characteristics remain largely unknown. Analysis of the effects of water quality perturbations on the benthic assemblages of the Plains ecoregions is further complicated by the dearth of information on the effects of salinization of surface waters on macroinvertebrates.

METHODS

Aquatic macroinvertebrates were sampled by personnel of the Montana Department of Environmental Quality (MT DEQ) from 10 sites in 3 reaches of the Redwater River and its East Fork on May 25 and 26, 1999. A replicate sample was taken at a single site*, for quality assurance purposes. Sampling sites were numbered and described as shown in the following table. Reference sites are indicated therein.

Table A. Sites sampled for Redwater River study. May 25 – 27, 1999.

Reach	Site number	Site description and location
1	R1-S3	Reach 1, Site 3. Lat. 47 08 57/ Long. 105 54 45.
	R1-S8	Reach 1, Site 8. Above Brockway bridge. Lat. 47 18 81/ Long. 105 46 01.
	R1-S9	Not described. *Reference site for Reach 1.* Lat. 47 17 38/ Long. 105 45 52.
2	2 B	18-21-50 (NE¼, SW¼). Lat. 47 34 40/ Long. 105 21 21.
	2 D* Replicate 1.	Above Circle. Lat. 47 23 45/ Long. 105 35 50.
	2 D* Replicate 2.	South of Circle, union bridge. North side.
	2 F	Below Circle STP. Lat. 47 25 30/ Long. 105 34 21.
3	3 A	Below Pasture Creek confluence. Lat. 47 42 58/ Long. 105 14 50.
	3 D	Nickwall crossing. Lat. 48 02 49/ Long. 105 12 59.
	3 EF	East Fork Redwater River: about ¼ mile above confluence with the Redwater. Lat./Long. data unavailable.
	3 F	Downstream from guaging station on Highway 201 bridge. Lat. 47 54 05/ Long. 105 13 29.
Little Dry Creek		Above Highway bridge. *Reference site for Reaches 2 and 3.*

In addition to macroinvertebrate sample collection, habitat quality was visually evaluated at each site and reported by means of the habitat assessment protocol for streams with glide/pool prevalence as recommended by Bukantis (1998). Macroinvertebrate samples and associated habitat data were delivered to Rhithron Biological Associates, Missoula, Montana, for laboratory and data analyses.

In the laboratory, subsamples of 300 (+/- 10%) organisms were taken from each sample. Community structure, function, and sensitivity to impact were characterized for each subsample using two analytical methods. In the first approach, benthic community attributes were compared to reference criteria established by MT DEQ for streams of both Plains ecoregions in the State, namely the Northwestern Great Plains and the Northwestern Glaciated Plains (Omernik et al. 1997). The ecoregional reference approach for the Plains ecoregions uses ten metrics (Bukantis 1998). Actual metric values were compared to the reference values to obtain metric scores. Biointegrity was estimated as the combined score for all metrics expressed as a percentage of the maximum possible score. On this basis, use support categories were assigned to each site, indicating whether full support of designated uses is probable, given the biotic community present at the site (Table3).

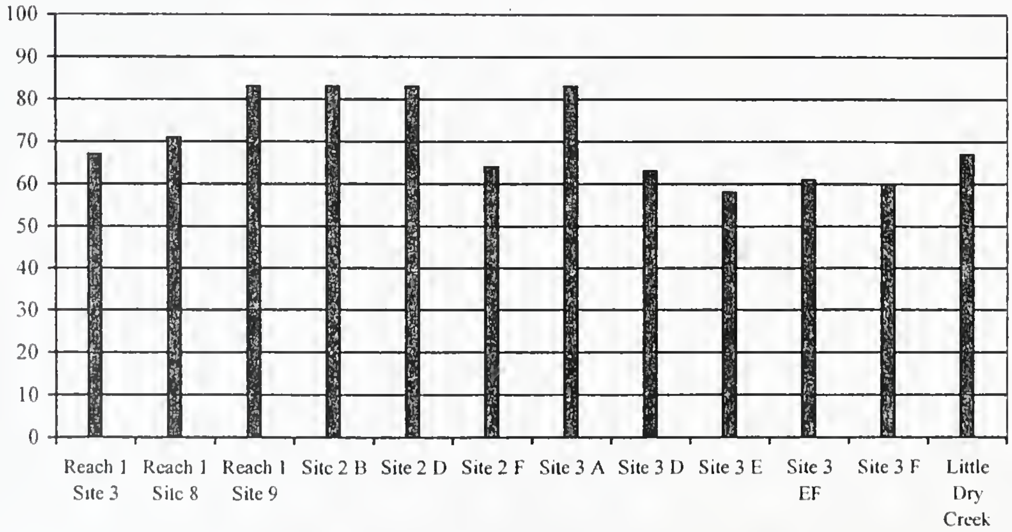
In the second approach, reference sites were selected from among the sites sampled because habitat conditions at these.sites appeared to be less impaired than at other sites. Metric values from these internal reference sites are used for comparisons of metric values from other sites. Table 5 gives the scoring criteria for metrics when internal reference criteria are used for generating metric scores for Plains ecoregions sites.

RESULTS

Habitat assessment

Figure 1a compares total habitat scores for all sites in the study. Scores illustrated

Figure 1a. Total habitat assessment scores as percent of maximum score for ten sites on the Redwater River, one site on the East Fork of the Redwater River, and one site on Little Dry Creek. May 25 - 27, 1999.



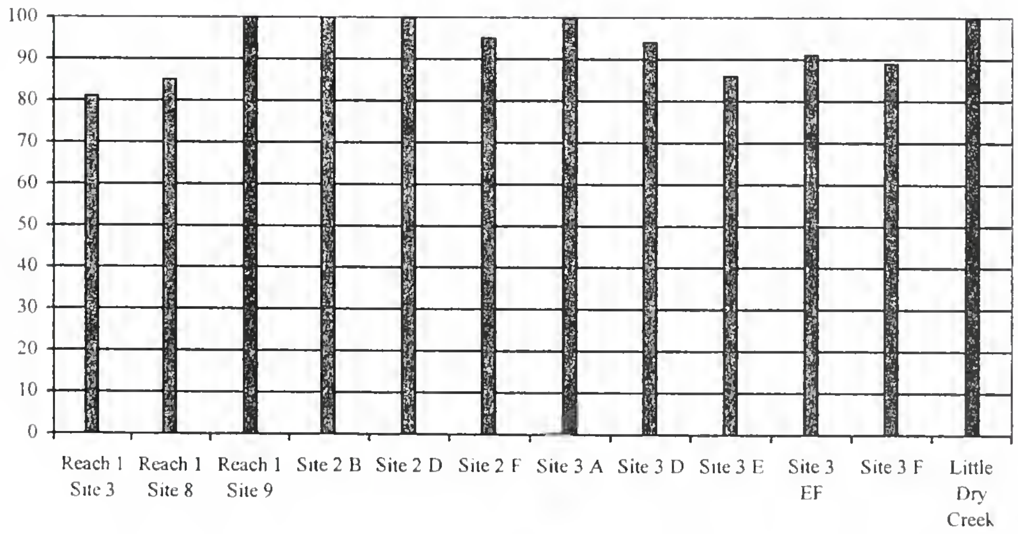
in the figure were calculated as a percent of the maximum possible score. An additional site was included in the habitat assessment for which there was no accompanying macroinvertebrate sample. This was site 3E, taken from a site upstream from Nickwall crossing.

Using this scoring method, four sites were judged to have optimal habitat: Reach 1 Site 9, Site 2B, Site 2D, and Site 3A. Scores for all other sites indicated sub-optimal habitat. In Reach 1, Site 9 had the highest habitat score. At Site 8, anaerobic sediments were noted. Shallow water depths characterized this site and Site 3. In Reach 2, mucky substrates in pools and some degree of channel alteration affected habitat scores.

In general, sites in Reach 3 and the Little Dry Creek site had lower habitat scores than either of the other two reaches, with the exception of the site below Pasture Creek (Site 3A), which scored optimally. Lower scores among the other sites in Reach 3 were partly due to abbreviated riparian vegetation zone widths, but these riparian vegetation zones were judged by DEQ personnel to be the maximum potential for the sites. Thus, habitat scores calculated as a percent of maximum possible score may not be accurate assessments for these sites.

Alternatively, habitat scores can be calculated as a percent of the scores attained by the respective reference sites, and applying this method gives quite different results. Figure 1b illustrates habitat assessment scores for the same sites calculated as a percent of reference condition.

Figure 1b. Total habitat assessment scores for ten sites on the Redwater River, one site on the East Fork of the Redwater River, and one site on Little Dry Creek. Scores calculated as percent of reference condition. Scores for reference sites are indicated by red bars. May 25 - 27, 1999.



Habitat conditions at all sites score optimally when an internal reference approach to habitat assessment is used. Table 1, which may be found in the "Tables" section of this report, shows scores for all habitat parameters for each site evaluated.

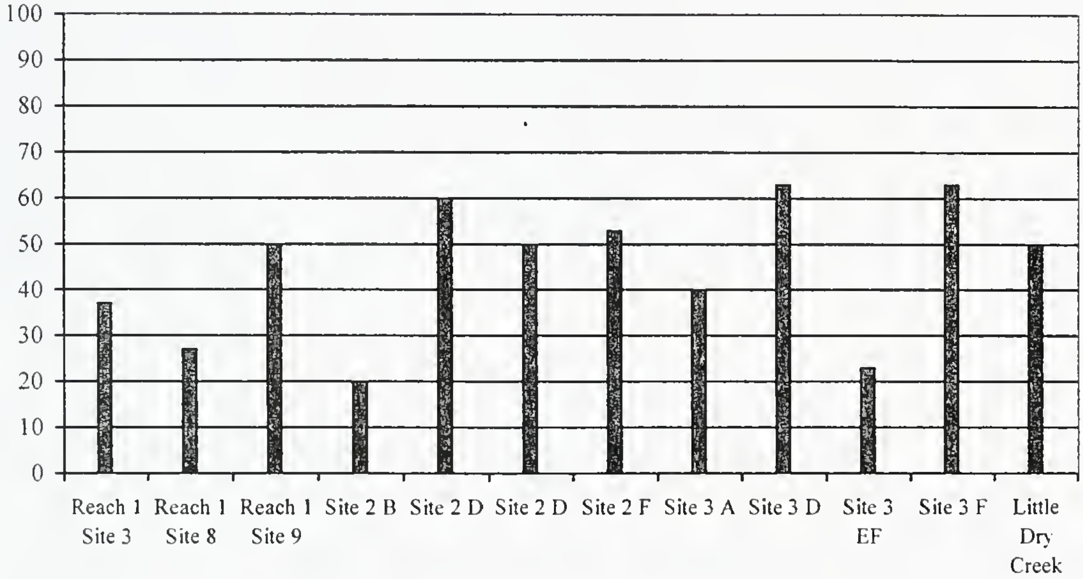
Bioassessments

Macroinvertebrate taxa lists, metric results and other information for each sample are given in the Appendix.

1. Plains ecoregions reference

Figure 2 compares total bioassessment scores for sampled sites based upon comparison with the Plains ecoregions reference (Bukantis 1998). Table 4 (a and b) displays scores for each metric.

Figure 2. Total bioassessment scores, based on Plains ecoregion reference (Bukantis 1998), for ten sites on the Redwater River, one site on the East Fork of the Redwater, and one site on Little Dry Creek. May 25 - 27, 1999. Site 2 D is represented by two replicate samples. No macroinvertebrate sample was available for Site 3 E.

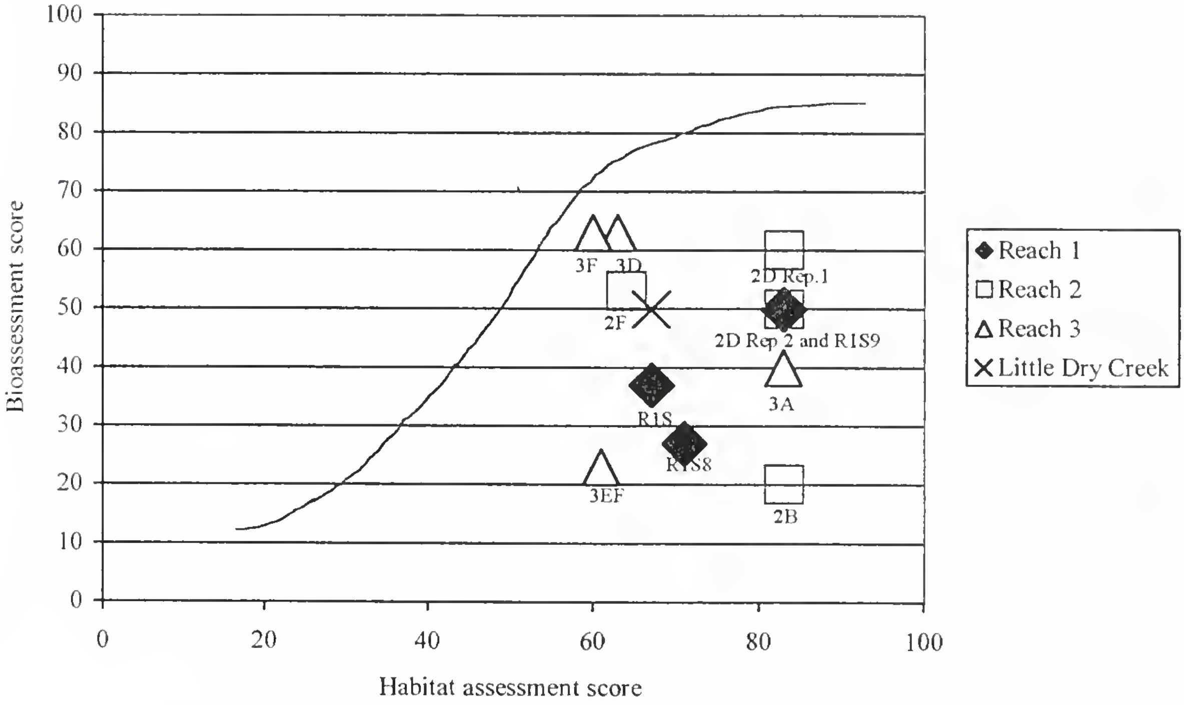


Two sites, 2B on the main Redwater River and 3EF on the East Fork, did not support designated uses, a condition considered to indicate severe impairment. All other sites received bioassessment scores that indicated partial support of designated uses, though one site, Reach 1 Site 8, scored very low within the partial-use-support category.

A technique that may be useful in distinguishing the effects of water quality perturbations from impacts due to habitat degradation is the graphing of the bioassessment score for each site against the site's habitat assessment score. Figure 4 is such a graph of the data from the Redwater River and the East Fork of the Redwater. The accuracy of such an analysis depends strongly on the adequacy of the bioassessment metric battery in distinguishing impairment, however, and, as mentioned previously, there is no such assurance concerning the battery used in this study. Where habitat degradation is the primary source of impact to biotic health, the expected relationship of bioassessment scores to habitat assessment scores is represented by a positively-directed, sigmoid-shaped curve (Barbour and Stribling 1991).

In Figure 4, Sites 2F, 3D, 3F and Little Dry Creek appear to lie in the region of the graph where habitat quality is determining the health of the benthic community mainly in the absence of water quality perturbations. The other sites lie below and/or to the right of these, indicating bioassessment scores lower than expected if habitat quality were the primary source of impairment. Such a finding suggests that impaired water quality may have been a factor inhibiting the health of the benthic community at these sites.

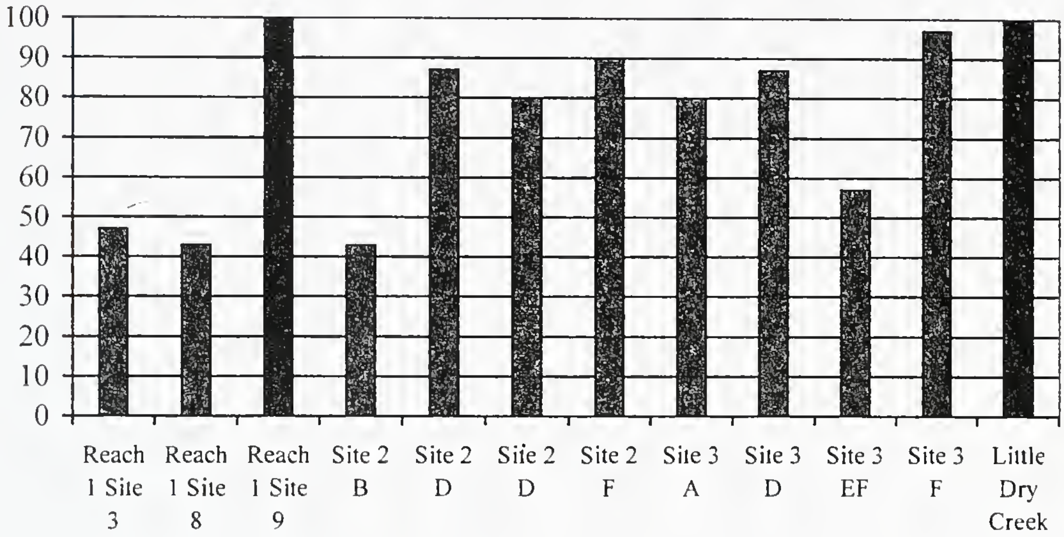
Figure 4. The relationship between total habitat assessment scores and total bioassessment scores for sampled sites on the Redwater River, its East Fork, and Little Dry Creek. May 25 - 27, 1999. The red line suggests the hypothetical expected relationship between habitat scores and bioassessment scores if habitat perturbations were the sole determinant of biotic conditions. Habitat scores were calculated as percent of maximum possible score, and bioassessment scores are based upon the ecoregional reference.



2. *Internal Reference*

DEQ personnel chose Site 9 in Reach 1 as the reference for other sites in Reach 1, and the site on Little Dry Creek as reference for sites in Reaches 2 and 3 of the Redwater River and the East Fork. Table 5 illustrates the scoring criteria applied in the internal reference approach. Table 6 shows the metric scoring for sites in Reach 1 using the internal reference, and Table 7 (a and b) shows the metric scoring for sites in Reaches 2 and 3.

Figure 5. Total bioassessment scores, based on an internal reference approach, for ten sites on the Redwater River, one site on the East Fork of the Redwater, and one site on Little Dry Creek. May 25 - 27, 1999. Site 2 D is represented by two replicate samples. No macroinvertebrate sample was available for Site 3 E. Scores for reference sites are indicated by red bars. Reach 1 Site 9 provided the reference for sites in Reach 1, and Little Dry Creek provided the reference for all other sites.



The internal reference approach to bioassessment yields much different results for these sites than the ecoregional reference approach. Figure 5 compares bioassessment scores when internal references were used as criteria. Given an *a priori* assessment of reference conditions for biotic health at Reach 1 Site 9 and at the site on Little Dry Creek, six other sites appear to have unimpaired biointegrity by comparison, and appear to fully support designated uses. Partial use support was indicated by scores for the two sites in Reach 1 and for Sites 2 B and 3 EF. No site is scored to indicate severe impairment, which was indicated by scores for two sites when the ecoregional reference was used.

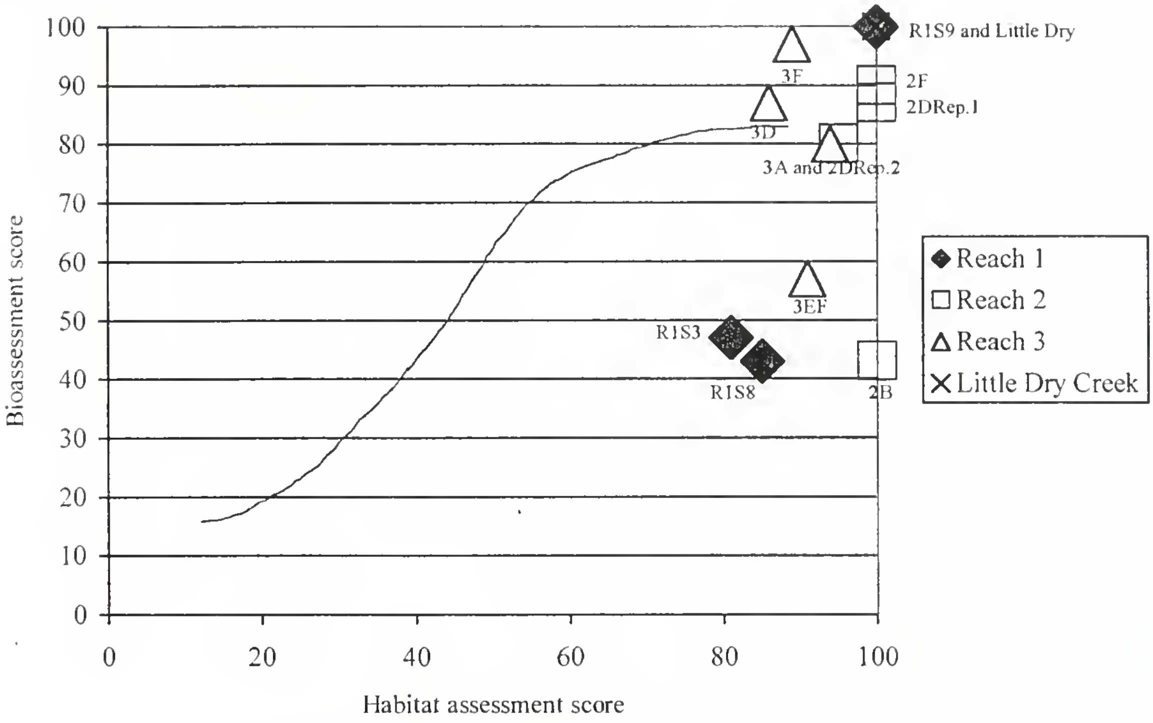
Graphing bioassessment scores against habitat assessment scores calculated using internal references as criteria gives the result illustrated in Figure 6. In this rendering, good water and habitat quality are suggested by the positions of symbols for all sites except Reach 1 Site 3, Reach 1 Site 8, Site 2B, and Site 3EF. For these four sites, high scores for habitat quality coupled with low bioassessment scores suggests that water quality perturbations are present, if habitat assessment and bioassessment methods are accurate.

Macroinvertebrate communities

- *Reach 1*

In Reach 1, benthic assemblages were characteristic of warm waters with little or no flow. Cladocerans (*Daphnia* sp.) were abundant at Site 3 and Site 8, while Site 9 was dominated by the midge *Paratanytarsus* sp., which is typically associated with the sediments of lake littoral zones. Dominance of the damselfly *Lestes* sp. at Site 3,

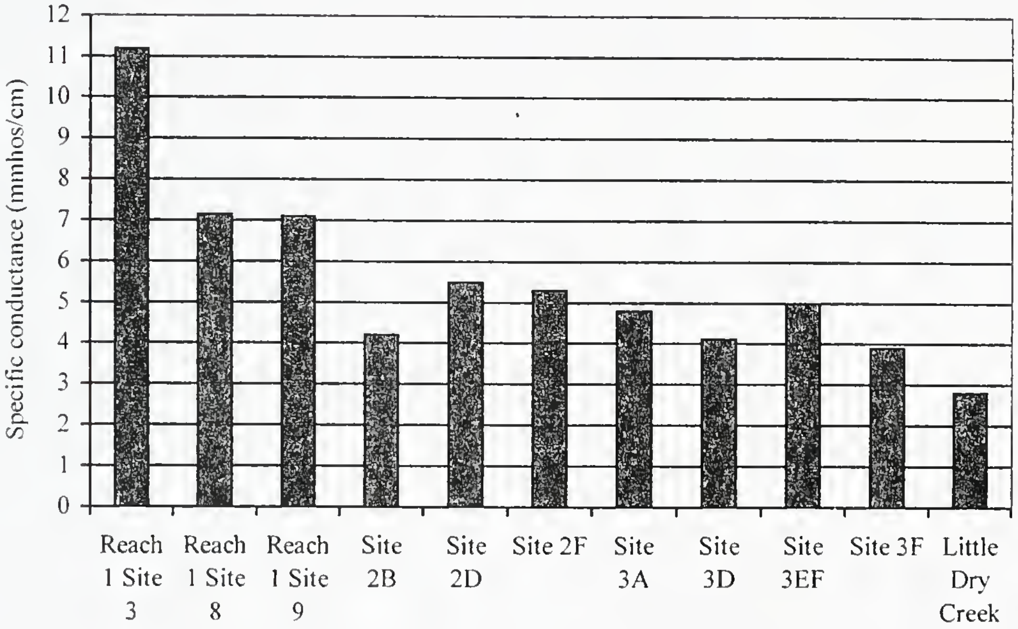
Figure 6. The relationship between total habitat assessment scores and total bioassessment scores for sampled sites on the Redwater River. its East Fork, and Little Dry Creek. May 25 - 27, 1999. The red line suggests the hypothetical expected relationship between habitat scores and bioassessment scores if habitat perturbations were the sole determinant of biotic conditions. Habitat scores were calculated as percent of reference condition, and bioassessment scores are based upon comparison to internal references.



comprising 36% of the sampled assemblage, suggests pond-like conditions with emergent vegetation. All three sites in Reach 1 scored poorly compared to the Plains ecoregions reference and Sites 3 and 8 scored poorly compared to Site 9, the internal reference, given the optimal or sub-optimal habitat assessment scores they received. This suggests that poor water quality may have contributed to diminished biotic health. It might also be the case, however, that the current bioassessment metric battery in use for these regions, with its inclusion of two metrics aimed at EPT as well as its optimistic scoring of these two metrics, may not adequately assess the health of near-lentic sites such as those found in the Redwater River. There was but a single EPT taxon collected in Reach 1; the mayfly *Caenis* sp., characteristic of lentic environments or in depositional zones of warm slow-flowing waters, was found in considerable abundance at Site 9 and less abundantly at Site 8. Significantly, *Caenis* sp. was not collected at Site 3. There is other evidence for poor water quality at all three sites; salinity, measured as specific conductance, was high for all sites in Reach 1, particularly Site 3. Figure 7 graphs the results of specific conductance measurements taken at each site.

Site 9 had a relatively diverse assemblage of organisms, and the highest taxa richness (23) of all sites studied. Nine midge taxa were collected here, suggesting variable substrate with diverse niches. By contrast, the assemblage at Site 8 was relatively depauperate, dominated by immature tubificid worms (36% of the sampled assemblage). Only 7 taxa were collected here, and overall macroinvertebrate abundance was quite low. The abundance of tubificid worms suggests that sediment deposition may impair habitat integrity at this site; their dominance of the community, along with the presence of other tolerant taxa, such as the midge *Tanypus* sp., nematodes and ceratopogonid flies, also suggests that nutrient and/or organic enrichment may impair water quality at this site. Further upstream, water quality impairment may also be a factor limiting biotic health at Site 3. There is not, however, a strong indication that the source of water quality impairment is organic or nutrient pollution. Instead, the damselfly *Lestes* sp. is well-known to be highly tolerant of saline conditions, and three of the other ten dominant taxa at this site are surface-dwelling animals, which are also tolerant of high conductivity. It is possible, though impossible to state with certainty, that high salinity at this site affects biotic health here. Abundance of macroinvertebrates was also low at Site 3, implicating high conductance as a source of water quality perturbation.

Figure 7. Specific conductance (mmhos/cm.) at Redwater River, East Fork and Little Dry Creek sites. May 25 – 27, 1999.



- *Reach 2*

In Reach 2, two samples yielded assemblages characteristic of warm lentic environments, while the two others suggested that they were collected from flowing water. At Site 2B, the blackfly *Simulium* sp. overwhelmingly dominated the collected assemblage, comprising 85% of the organisms sampled. This filter-feeding organism needs at least some flow to thrive, and its abundance strongly suggests that fine particulate organic matter was plentiful in the Redwater River at this site. Organic and/or nutrient inputs to the water are also suggested by the midge fauna collected at the site, including *Pseudochironomus* sp., and *Dicrotendipes* sp., both characteristic organisms of meso- or eutrophic conditions.

At Site 2D (labeled "South of Circle"), *Simulium* sp. constituted 21% of sampled organisms. Warm water and ample nutrients are suggested by the dominance of the snail *Physella* sp., which comprised 43% of the assemblage in the sample.

Assemblages at Sites 2D (labeled "Above Circle") and Site 2F were mainly comprised of organisms with lentic associations. Cladocera (*Daphnia* sp.) made up 25% of animals sampled at Site 2D, and the midge *Paratanytarsus* sp. dominated the assemblage (40%) at Site 2F. Organic and/or nutrient enrichment of the water is suggested by the benthic community composition at all sites in Reach 2: dominant organisms include *Simulium* sp., physid and lymnaeid snails and tolerant midges. Abundant macroinvertebrates were present in samples from all sites in Reach 2, suggesting that excessive salinity was not a major contributor to water quality perturbations in this reach.

- *Reach 3*

In Reach 3, low numbers of organisms were collected at Sites 3D and 3F, and while this may suggest severe habitat degradation or water quality impairment, it is more likely a natural finding in the lower reaches of plains rivers, where sediments are fine and habitat relatively monotonous. The assemblages collected here have rather large components of sediment-tolerant organisms, particularly the elmid beetle *Dubiraphia* sp., which is almost exclusively found among fine sediments in lotic systems. Site 3F also harbored the burrowing mayfly *Hexagenia limbata* suggesting a large riverine environment and fine sediments. Tubificid worms were abundant at Site 3D, comprising 16% of the sampled assemblage, implicating water quality perturbations due to organic and/or nutrient enrichment.

Macroinvertebrates were abundant at Site 3A in the Redwater River and Site 3EF in the East Fork of the Redwater. Both sites were dominated by the blackfly *Simulium* sp., which comprised 50% of the assemblage at Site 3A and overwhelmed the community at the East Fork site at 85% of organisms. Other indications of fine organic particulates and nutrient enrichment were present at both sites as well. For example, physid snails (*Physella* sp.) were among the dominant organisms at both sites, and the pollution-tolerant mayfly *Caenis* sp. was similarly abundant.

CONCLUSIONS

- The performance of bioassessment metrics and metric batteries for streams of the Plains ecoregions have not yet been examined thoroughly enough to determine whether or not the individual metrics or their integrated scores can discriminate impaired conditions from good biotic health. Benthic assemblages and their function in these systems are poorly understood, and relationships between communities, habitat parameters (such as sedimentation and flow conditions), and water quality factors (such as salinity and water temperature) on which bioassessments can be based are not yet well established. The metric battery recommended by Montana DEQ for the Plains ecoregions may not discriminate impairment in conditions of slow flow and warmer water temperatures, which may be normal stream conditions in these regions. Observations and conclusions offered in this report are thus to be considered provisional.

- Sites in Reach 1 appeared to have impaired biotic health that could be attributed at least partly to water quality impairment. Salinity could be among the possible causes of low macroinvertebrate abundance and dominance of tolerant organisms. Warm water temperatures and near-lentic flow conditions were indicated throughout the reach. Nutrient and/or organic enrichment was indicated by the taxonomic composition of benthic communities in this reach. Low total abundance of organisms in samples from Sites 3 and 8 in Reach 1 implicate salinity as an additional source of impairment at these sites.
- Organic and/or nutrient enrichment was indicated by communities collected in Reach 2. Benthic organisms appeared to be abundant throughout the reach. No specific indication of increased salinity was noted.
- Fine sediments and relatively monotonous habitat conditions appeared to determine the composition of communities in Reach 3, which also appeared to take on characteristics of a large riverine system in its lowest sampled reach. Again, nutrient and/or organic enrichment was suggested by the benthic assemblages throughout the reach.
- For quality control purposes, sampling was replicated at Site 2D. The coefficient of variation (*V*) for bioassessment scores calculated for both replicates was 10.9% when the ecoregional reference was used, and 4.2% when the internal reference was used. These figures suggest that the internal reference method produced scores with better replicability. However, taxonomic composition of communities sampled in the two replicates was quite different. Of 28 total taxa collected at Site 2D in both replicate samples, the individual samples had only 11, or 39%, in common. As mentioned earlier in this report, the replicate labeled "Above Circle" contained an assemblage indicative of near-lentic conditions, whereas that labeled "South of Circle" contained a significant number of organisms associated with lotic conditions. It would appear that the low value for *V* obtained with the use of internal reference criteria should be considered spurious, and not a validation of the either the sampling technique or the bioassessment method.

TABLES

Table 1. Habitat assessments (glide/pool prevalence) for Redwater River study sites. May 25 - 27, 1999.

Max. score	*Habitat parameter*	*Reach I Site 3*	*Reach I Site 8*	*Reach I Site 9*	*Site 2 B*	*Site 2 D: Above Circle*	*Site 2 F: Below Circle STP*	*Site 3A: Callison site- below Pasture Creek confluence*	*Site 3D: Nickwall crossing*	*Site 3E: upstream about 100 yards from Nickwall crossing*[1]	*Site 3 EF: East Fork Redwater River, about ¼ mile above confluence*	*Site F: Below guaging station on Highway 201 bridge*	*Little Dry Creek: above highway bridge*
20	Bottom substrate-available cover	16	6	15	15	15	13	13	10	10	15	10	8
20	Pool substrate characterization	15	9	16	18	11	15	15	10	12	16	16	10
20	Pool variability	7	11	12	18	17	16	18	14	12	16	12	18
20	Channel alteration	20	20	20	19	19	7	16	18	17	18	17	20
20	Sediment deposition	10	6	19	18	11	16	18	12	16	17	16	15
20	Channel sinuosity	8	15	14	13	18	10	12	10	8	10	8	10
20	Channel flow status	10	18	19	19	20	18	19	16	16	16	16	16
10 / 10	Bank vegetation protection (left / right)	6 / 7	8 / 8	9 / 8	9 / 9	10 / 10	8 / 8	9 / 9	7 / 7	5 / 5	9 / 9	6 / 6	9 / 9
10 / 10	Bank stability (left / right)	9 / 9	10 / 10	9 / 9	9 / 9	10 / 10	6 / 6	9 / 9	9 / 9	5 / 5	10 / 10	4 / 4	8 / 7
10 / 10	Riparian vegetation zone width (left / right)	9 / 8	10 / 10	8 / 8	5 / 5	9 / 6	2 / 2	9 / 9	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2
TOTAL SCORE		134	141	166	166	166	127	165	126	115	122	119	134
PERCENT OF MAX. SCORE (200)		67	71	83	83	83	64	83	63	58	61	60	67
CONDITION*		SUB-OPTIMAL	SUB-OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL	SUB-OPTIMAL	OPTIMAL	SUB-OPTIMAL	SUB-OPTIMAL	SUB-OPTIMAL	SUB-OPTIMAL	SUB-OPTIMAL
PERCENT OF REFERENCE CONDITION[2]		81	85	100	100	100	95	100	94	86	91	89	100
CONDITION*		OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL

*Condition categories: Optimal >81% of maximum possible score; Sub-optimal 75-56%; Marginal 49-29%; Poor <23%.

[1] No macroinvertebrate sample for this site was available.

[2] Reference condition for sites in Reach 1 was defined by conditions at Reach 1 Site 9. Reference condition for sites in Reaches 2 and 3 was defined by conditions at Little Dry Creek.

Table 2. Metrics and scoring criteria for Plains ecoregions streams (Bukantis 1998).

	Scoring Criteria			
metric	3	2	1	0
Taxa richness	>24	24 - 18	18 - 12	<12
EPT richness	>8	8 - 6	5 - 3	<3
Biotic index	<5	5 - 6	6 - 7	>7
% dominant taxon	<30	30 - 45	45 - 60	>60
% collectors	<60	60 - 80	80 - 95	>95
% EPT	>50	50 - 30	30 - 10	<10
Shannon diversity	>3.0	3.0 – 2.4	2.4 – 1.8	<1.8
% scrapers + shredders	>30	30 - 15	15 - 3	<3
Predator taxa richness	>5	4 - 5	3 - 4	<3
% multivoltine	<40	40 - 60	60 - 80	>80

Table 3. Criteria for the assignment of support classifications / standards violation thresholds (from Bukantis, 1998)

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table 4a. Metric values, scores and bioassessments for sites in the Redwater River study. Plains ecoregion criteria per Bukantis (1998).

metric	**Reach 1, Site 3**	**Reach 1, Site 8**	**Reach 1, Site 9**	**Site 2B**	**Site 2D, Above Circle**	**Site 2D, South of Circle**
Taxa richness	14	7	23	9	16	20
EPT richness	0	1	2	1	1	2
Biotic index	7.91	8.63	6.48	5.23	6.71	7.02
% dominant taxon	36	38	46	85	25	43
% Collector (g+ff)	50	69	34	96	46	39
% EPT	0	6	11	7	<1	2
Shannon diversity(log2)	2.41	2.44	2.98	0.92	3.03	2.53
% Scrapers + Shredders	0	0	4	0	17	44
# predator taxa	3	2	5	3	4	3
% multivoltine	47	44	55	3	43	14
metric score						
Taxa richness	1	0	2	0	2	1
EPT richness	0	0	0	0	0	0
Biotic index	0	0	1	2	1	0
% dominant taxon	2	2	1	0	3	2
% Collector (g+ff)	3	2	3	0	3	3
% EPT	0	0	1	0	0	0
Shannon diversity(log2)	2	2	2	0	3	2
% Scrapers + Shredders	0	0	1	0	2	3
# predator taxa	1	0	2	1	2	1
% multivoltine	2	2	2	3	2	3
total score (max = 30)	11	8	15	6	18	15
% reference	37	27	50	20	60	50
use support*	**PART**	**PART**	**PART**	**NON**	**PART**	**PART**

* See Table 3 for use support designation criteria. FULL = full use support; PART = partial use support; NON = uses not supported.

Table 4b. Metric values, scores and bioassessments for sites in the Redwater River study. Plains ecoregion criteria per Bukantis (1998).

metric	**Site 2F**	**Site 3A Below Pasture Creek**	**Site 3D Nickwall Crossing**	**Site 3EF**	**Site 3F**	**Little Dry Creek**
Taxa richness	20	16	13	12	18	20
EPT richness	1	2	3	1	4	2
Biotic index	6.57	5.83	6.45	5.32	6.11	4.51
% dominant taxon	40	50	26	85	36	31
% Collector (g+ff)	36	80	51	97	48	81
% EPT	26	17	22	10	41	38
Shannon diversity(log2)	2.74	2.39	3.00	0.93	2.68	3.06
% Scrapers + Shredders	5	7	10	1	5	<1
# predator taxa	4	2	4	2	4	3
% multivoltine	41	9	6	2	10	34
metric score						
Taxa richness	2	1	1	1	2	2
EPT richness	0	0	1	0	1	0
Biotic index	1	2	1	2	1	1
% dominant taxon	2	1	3	0	2	2
% Collector (g+ff)	3	2	3	0	3	1
% EPT	1	1	1	1	2	2
Shannon diversity(log2)	2	1	3	0	2	3
% Scrapers + Shredders	1	1	1	0	1	0
# predator taxa	2	0	2	0	2	1
% multivoltine	2	3	3	3	3	3
total score (max = 30)	16	12	19	7	19	15
% reference	53	40	63	23	63	50
use support*	**PART**	**PART**	**PART**	**NON**	**PART**	**PART**

* See Table 3 for use support designation criteria. FULL = full use support; PART = partial use support; NON = uses not supported.

Table 5. Internal reference values and criteria for assigning scores to metrics based on percent comparability to reference values.

metric	*Redwater River Reach 1 Site 9 (reference for Reach 1)*	*Little Dry Creek (reference for Reaches 2 and 3)*	Scoring Criteria[2]				
			3	2	1	0	*
Taxa richness	23	20	> 85%	85-75%	75-60%	< 60%	a
EPT richness	2	2	> 80%	80-50%	50-35%	< 35%	a
Biotic index	6.48	6.35	> 90%	90-80%	80-70%	< 70%	b
% dominant taxon	46	31	> 75%	75-60%	60-50%	< 50%	b
%Collector(g+ff)	34	81	> 90%	90-75%	75-60%	< 60%	b
% EPT	11	38	> 85%	85-75%	75-40%	< 40%	a
Shannon diversity (log2)	2.98	3.06	>90%	90-80%	80-70%	<70%	a
% Scrapers and shredders	4	<1	>80%	80-50%	50-10%	<10%	a
# predator taxa	5	3	>60%	60-50%	50-40%	<40%	a
% multivoltine	55	34	>35%	35-25%	25-15%	<15%	b

[2] Scoring criteria are based on an analysis of metric ranges for 17 Plains Ecoregions sites in four years of data collected by the Montana Department of Environmental Quality (Bollman, unpublished data).

* a = score is ratio of study site to reference x 100.

* b = score is ratio of reference to study site x 100.

Table 6. Metric values expressed as percent of internal reference, scores, and bioassessments for Redwater River, Reach 1 sites. May 25 - 27,1999.

Metric	Reach 1 Site 3	Reach 1 Site 8	Reach 1 Site 9 (reference)
Taxa richness	61	30	100
EPT richness	0	50	100
Biotic index	82	75	100
% Dominant taxon	100	100	100
% Collectors	68	49	100
% EPT	0	55	100
Shannon H	81	82	100
% Scrapers plus shredders	0	0	100
# Predator taxa	60	40	100
% Multivoltine	100	100	100
Metric score			
Taxa richness	1	0	3
EPT richness	0	2	3
Biotic index	2	1	3
% Dominant taxon	3	3	3
% Collectors	1	0	3
% EPT	0	1	3
Shannon H	2	2	3
% Scrapers plus shredders	0	0	3
# Predator taxa	2	1	3
% Multivoltine	3	3	3
Total score (maximum = 30)	14	13	30
Percent of maximum	47	43	100
Use support *	**PART**	**PART**	**FULL**

* See Table 3 for use support designation criteria. FULL = full use support; PART = partial use support; NON = uses not supported.

Table 7a. Metric values expressed as percent of internal reference, scores, and bioassessments for sites in Reach 2, Redwater River. May 25 – 27, 1999.

metric	**Site 2B**	**Site 2D, Above Circle**	**Site 2D, South of Circle**	**Site 2F**
Taxa richness	45	100	80	100
EPT richness	50	50	100	50
Biotic index	100	95	90	97
% dominant taxon	36	100	72	78
% Collector (g+ff)	84	100	100	100
% EPT	18	2	5	68
Shannon diversity(log2)	30	99	83	90
% Scrapers + Shredders	0	100	100	100
# predator taxa	100	100	100	100
% multivoltine	100	79	100	83
metric score				
Taxa richness	0	3	2	3
EPT richness	2	2	3	2
Biotic index	3	3	3	3
% dominant taxon	0	3	2	3
% Collector (g+ff)	2	3	3	3
% EPT	0	0	0	1
Shannon diversity(log2)	0	3	2	3
% Scrapers + Shredders	0	3	3	3
# predator taxa	3	3	3	3
% multivoltine	3	3	3	3
total score (max = 30)	13	26	24	27
% reference	43	87	80	90
use support*	**PART**	**FULL**	**FULL**	**FULL**

*See Table 3 for use support designation criteria. FULL = full use support; PART = partial use support; NON = uses not supported.

Table 7b. Metric values expressed as percent of internal reference, scores, and bioassessments for sites in Reach 3 of the Redwater River and the Little Dry Creek reference site. May 25 – 27, 1999.

metric	**Site 3A Below Pasture Creek**	**Site 3D Nickwall Crossing**	**Site 3EF**	**Site 3F**	**Little Dry Creek**
Taxa richness	80	65	60	90	100
EPT richness	100	100	50	100	100
Biotic index	100	98	100	100	100
% dominant taxon	62	100	36	86	100
% Collector (g+ff)	100	100	84	100	100
% EPT	45	58	26	100	100
Shannon diversity(log2)	78	98	30	88	100
% Scrapers + Shredders	100	100	100	100	100
# predator taxa	67	100	67	100	100
% multivoltine	100	100	100	100	100
metric score					
Taxa richness	2	1	1	3	3
EPT richness	3	3	2	3	3
Biotic index	3	3	3	3	3
% dominant taxon	2	3	0	3	3
% Collector (g+ff)	3	3	2	3	3
% EPT	1	1	0	3	3
Shannon diversity(log2)	1	3	0	2	3
% Scrapers + Shredders	3	3	3	3	3
# predator taxa	3	3	3	3	3
% multivoltine	3	3	3	3	3
total score (max = 30)	24	26	17	29	30
% reference	80	87	57	97	100
use support*	**FULL**	**FULL**	**PART**	**FULL**	**FULL**

* See Table 3 for use support designation criteria. FULL = full use support; PART = partial use support; NON = uses not supported.

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Aquatic Macroinvertebrate Data: Little Dry Creek. May 27, 1999.

Percent of sample used	100
Subsample size	194
Percent EPT	38
Taxa richness	20
EPT richness	2
Biotic Index	6.35
Percent dominant taxon	31.44
Percent dominance of five dominant taxa	79.37
Percent dominance of ten dominant taxa	95.36
Percent collectors (gatherers plus filterers)	81.46
Percent scrapers plus shredders	.52
Percent Hydropsychinae of Trichoptera	1.00
Metals tolerance index	4.51
Shannon H (log2)	3.06
Evenness	.73
Brillouin H	1.98
Simpson D	.17
EPT/Chironomidae	.88
CTQa	04.00
Percent Baetidae of Ephemeroptera	0
%Ephemeroptera	31.44
%Plecoptera	.00
%Trichoptera	6.19
%Coleoptera	.00
%Diptera	5.68
%Chironomidae	42.80
Multivoltine	34.15
Univoltine	64.82
Semivoltine	1.03

Functional Feeding Groups	# taxa	% abundance
Predator	3	7.22
Collector-gatherer	9	74.75
Collector-filterer	2	6.71
Scraper	1	.52
Shredder	0	.00

Estimated total number of organisms 194

15 pool 5 riffle, 20 jabs

Macroinvertebrate Taxonomic Data

Little Dry Creek above highway bridge. May 27, 1999.

Taxon	#	%	BI	FFG
Oligochaeta: Naididae 2 Lumbriculidae 1 Tubificidae 1	4	2.06	10	CG
Physidae	1	0.52	8	SC
Acari	1	0.52	5	PA
TOTAL: MISC. TAXA	6	3.09		
Coenagrionidae: Enallagma	2	1.03	7	PR
TOTAL: ODONATA	2	1.03		
Caenis	61	31.44	7	CG
TOTAL: EPHEMEROPTERA	61	31.44		
Corixidae	19	9.79	5	UN
TOTAL: HEMIPTERA	19	9.79		
Cheumatopsyche	12	6.19	5	CF
TOTAL: TRICHOPTERA	12	6.19		
Ceratopogonidae	9	4.64	6	PR
Simulium	1	0.52	5	CF
Ormosia	1	0.52	6	CG
TOTAL: DIPTERA	11	5.67		
Cricotopus (Isocladius) intersectus	24	12.37	7	CG
Cryptochironomus	3	1.55	8	CG
Dicrotendipes	15	7.73	8	CG
Micropsectra	1	0.52	4	CG
Paratanytarsus	1	0.52	6	UN
Polypedilum	1	0.52	6	CG
Pseudochironomus	35	18.04	5	CG
Thienemannimyia	3	1.55	5	PR
TOTAL: CHIRONOMIDAE	83	42.78		
GRAND TOTAL	194	100.00		

APPENDIX

Macroinvertebrate Taxonomic Data

Redwater River Reach 1 Site 3

Taxon		#	%	BI	FFG
Cladocera		72	32.58	8	CF
Ostracoda		10	4.52	8	CG
TOTAL: MISC. TAXA		82	37.10		
Lestidae: Lestes		79	35.75	9	PR
TOTAL: ODONATA		79	35.75		
Corixidae		19	8.60	5	UN
TOTAL: HEMIPTERA		19	8.60		
Curculionidae		2	0.90	11	UN
Dytiscidae		9	4.07	5	PR
Rhantus	1				
Coptotomus	3				
Hygrotus	3				
Laccophilus	1				
TOTAL: COLEOPTERA		11	4.98		
Ceratopogonidae		1	0.45	6	PR
TOTAL: DIPTERA		1	0.45		
Chironomus		1	0.45	10	CG
Cricotopus Isocladius		12	5.43	7	CG
Psectrocladius		15	6.79	8	CG
Tanytarsus		1	0.45	6	CF
TOTAL: CHIRONOMIDAE		29	13.12		
GRAND TOTAL		221	100.00		

Aquatic Macroinvertebrate Data: Redwater River Reach 1 Site 3. May 25, 1999.

Percent of sample used	100
Subsample size	221
Percent EPT	0
Taxa richness	11
EPT richness	0
Biotic Index	7.91
Percent dominant taxon	35.75
Percent dominance of five dominant taxa	89.15
Percent dominance of ten dominant taxa	99.54
Percent collectors (gatherers plus filterers)	50.22
Percent scrapers plus shredders	0
Percent Hydropsychinae of Trichoptera	00
Shannon H (log2)	2.41
Evenness	.70
Brillouin H	1.59
Simpson D	.25
EPT/Chironomidae	.00
CTQa	104.40
Percent Baetidae of Ephemeroptera	0
%Ephemeroptera	.00
%Plecoptera	.00
%Trichoptera	.00
%Coleoptera	4.97
%Diptera	.45
%Chironomidae	13.12
Multivoltine	46.95
Univoltine	48.98
Semivoltine	4.07

Functional Feeding Groups	# taxa	% abundance
Predator	3	40.27
Collector-gatherer	4	17.19
Collector-filterer	2	33.03
Scraper	0	.00
Shredder	0	.00

Estimated total number of organisms	221
Estimated number collected per foot	unknown
Estimated number collected per minute	unknown

Macroinvertebrate Taxonomic Data

Redwater River Reach 1 Site 8

Taxon	#	%	BI	FFG
Nematoda	9	6.25	5	OM
Oligochaeta: Tubificidae	54	37.50	10	CG
Cladocera	27	18.75	8	CF
TOTAL: MISC. TAXA	90	62.50		
Caenis	9	6.25	7	CG
TOTAL: EPHEMEROPTERA	9	6.25		
Ceratopogonidae	9	6.25	6	PR
TOTAL: DIPTERA	9	6.25		
Tanypus	27	18.75	10	PR
Tanytarsus	9	6.25	6	CF
TOTAL: CHIRONOMIDAE	36	25.00		
GRAND TOTAL	144	100.00		

Aquatic Macroinvertebrate Data: Redwater River Reach 1 Site 8. May 26, 1999.

Percent of sample used	100
Subsample size	144
Percent EPT	6
Taxa richness	7
EPT richness	1
Biotic Index	8.63
Percent dominant taxon	37.50
Percent dominance of five dominant taxa	87.50
Percent dominance of ten dominant taxa	100.00
Percent collectors (gatherers plus filterers)	68.75
Percent scrapers plus shredders	0
Percent Hydropsychinae of Trichoptera	00
Shannon H (log2)	2.44
Evenness	.87
Brillouin H	1.60
Simpson D	.22
EPT/Chironomidae	.25
CTQa	102.86
Percent Baetidae of Ephemeroptera	0
%Ephemeroptera	6.25
%Plecoptera	.00
%Trichoptera	.00
%Coleoptera	.00
%Diptera	6.25
%Chironomidae	25.00
Multivoltine	43.75
Univoltine	37.50
Semivoltine	18.75

Functional Feeding Groups	# taxa	% abundance
Predator	2	25.00
Collector-gatherer	2	43.75
Collector-filterer	2	25.00
Scraper	0	.00
Shredder	0	.00

Estimated total number of organisms 144

20 jabs, each 20 feet. 60 feet total.

Macroinvertebrate Taxonomic Data

Redwater River Reach 1 Site 9

Taxon	#	%	BI	FFG
Oligochaeta: Tubificidae	2	0.62	10	CG
Lymnaeidae	9	2.80	6	SC
Gyraulus	1	0.31	8	SC
Cladocera	2	0.62	8	CF
Copepoda	8	2.49	8	CG
Acari	8	2.49	5	PA
TOTAL: MISC. TAXA	30	9.35		
Aeshna	1	0.31	5	PR
Coenagrionidae: Enallagma	27	8.41	7	PR
Lestidae: Lestes	3	0.93	9	PR
TOTAL: ODONATA	31	9.66		
Caenis	34	10.59	7	CG
TOTAL: EPHEMEROPTERA	34	10.59		
Corixidae	7	2.18	5	UN
TOTAL: HEMIPTERA	7	2.18		
Oecetis	1	0.31	8	PR
TOTAL: TRICHOPTERA	1	0.31		
Dytiscidae: Ilybius	1	0.31	5	PR
Dubiraphia	4	1.25	6	SC
TOTAL: COLEOPTERA	5	1.56		
Chironomus	1	0.31	10	CG
Corynoneura	6	1.87	7	CG
Cricotopus Isocladius	16	4.98	7	CG
Dicrotendipes	21	6.54	8	CG
Glyptotendipes	3	0.93	10	CG
Micropsectra	6	1.87	4	CG
Paratanytarsus	149	46.42	6	UN
Polypedilum	1	0.31	6	CG
Tanytarsus	10	3.12	6	CF
TOTAL: CHIRONOMIDAE	213	66.36		
GRAND TOTAL	321	100.00		

Aquatic Macroinvertebrate Data: Redwater River Reach 1 Site 9. May 26, 1999.

Percent of sample used	67
Subsample size	321
Percent EPT	11
Taxa richness	23
EPT richness	2
Biotic Index	6.48
Percent dominant taxon	46.42
Percent dominance of five dominant taxa	76.94
Percent dominance of ten dominant taxa	90.02
Percent collectors (gatherers plus filterers)	34.25
Percent scrapers plus shredders	4.36
Percent Hydropsychinae of Trichoptera	00
Shannon H (log2)	2.98
Evenness	.66
Brillouin H	1.95
Simpson D	.24
EPT/Chironomidae	.16
CTQa	100.78
Percent Baetidae of Ephemeroptera	0
%Ephemeroptera	10.59
%Plecoptera	.00
%Trichoptera	.31
%Coleoptera	1.56
%Diptera	.00
%Chironomidae	66.35
Multivoltine	55.37
Univoltine	42.45
Semivoltine	2.18

Functional Feeding Groups	# taxa	% abundance
Predator	5	10.27
Collector-gatherer	10	30.51
Collector-filterer	2	3.74
Scraper	3	4.36
Shredder	0	.00

Estimated total number of organisms 482

20 jabs, 3 feet each. 60 feet total.

Macroinvertebrate Taxonomic Data

Redwater River 2B

Taxon	#	%	BI	FFG
Oligochaeta: Tubificidae	1	0.34	10	CG
TOTAL: MISC. TAXA	1	0.34		
Caenis	20	6.90	7	CG
TOTAL: EPHEMEROPTERA	20	6.90		
Corydalidae: Oronectes	1	0.34	0	PR
TOTAL: MEGALOPTERA	1	0.34		
Ceratopogonidae	11	3.79	6	PR
Simulium	247	85.17	5	CF
TOTAL: DIPTERA	258	88.97		
Dicrotendipes	6	2.07	8	CG
Micropsectra	1	0.34	4	CG
Pseudochironomus	2	0.69	5	CG
Thienemannimyia	1	0.34	5	PR
TOTAL: CHIRONOMIDAE	10	3.45		
GRAND TOTAL	290	100.00		

Aquatic Macroinvertebrate Data: Redwater River 2B. (18-21-50 NE¼ SW¼). May 25, 1999.

Percent of sample used	7
Subsample size	290
Percent EPT	7
Taxa richness	9
EPT richness	1
Biotic Index	5.23
Percent dominant taxon	85.17
Percent dominance of five dominant taxa	98.62
Percent dominance of ten dominant taxa	99.98
Percent collectors (gatherers plus filterers)	95.51
Percent scrapers plus shredders	0
Percent Hydropsychinae of Trichoptera	00
Shannon H (log2)	.92
Evenness	.29
Brillouin H	.60
Simpson D	.73
EPT/Chironomidae	2.00
CTQa	103.50
Percent Baetidae of Ephemeroptera	0
%Ephemeroptera	6.90
%Plecoptera	.00
%Trichoptera	.00
%Coleoptera	.00
%Diptera	88.96
%Chironomidae	3.44
Multivoltine	2.59
Univoltine	96.90
Semivoltine	.52

Functional Feeding Groups	# taxa	% abundance
Predator	3	4.47
Collector-gatherer	5	10.34
Collector-filterer	1	85.17
Scraper	0	.00
Shredder	0	.00

Estimated total number of organisms 4143
Jab sample.

Macroinvertebrate Taxonomic Data

Redwater River 2D Above Circle

Taxon		#	%	BI	FFG
Lymnaeidae		52	16.67	6	SC
Physidae		1	0.32	8	SC
Cladocera		77	24.68	8	CF
Ostracoda		1	0.32	8	CG
Hyallela azteca		13	4.17	8	CG
Acari		14	4.49	5	PA
TOTAL: MISC. TAXA		158	50.64		
Libellulidae: Sympetrum		1	0.32	9	PR
Coenagrionidae		75	24.04	7	PR
Enallagma	63				
Ischnura	12				
TOTAL: ODONATA		76	24.36		
Callibaetis		1	0.32	9	CG
TOTAL: EPHEMEROPTERA		1	0.32		
Corixidae		3	0.96	5	UN
TOTAL: HEMIPTERA		3	0.96		
Brychius		1	0.32	5	SH
TOTAL: COLEOPTERA		1	0.32		
Ceratopogonidae		17	5.45	6	PR
Simulium		1	0.32	5	CF
TOTAL: DIPTERA		18	5.77		
Chironomus		1	0.32	10	CG
Cladopelma		2	0.64	9	CG
Dicrotendipes		2	0.64	8	CG
Endochironomus		6	1.92	10	CG
Micropsectra		37	11.86	4	CG
Paratanytarsus		3	0.96	6	UN
Procladius		2	0.64	9	CG
Psectrocladius		1	0.32	8	CG
Tanypus		1	0.32	10	PR
TOTAL: CHIRONOMIDAE		55	17.63		
GRAND TOTAL		312	100.00		

Aquatic Macroinvertebrate Data: Redwater River 2D Above Circle. May 26, 1999.

Percent of sample used	10
Subsample size	312
Percent EPT	<1
Taxa richness	22
EPT richness	1
Biotic Index	6.71
Percent dominant taxon	24.68
Percent dominance of five dominant taxa	82.70
Percent dominance of ten dominant taxa	95.20
Percent collectors (gatherers plus filterers)	46.15
Percent scrapers plus shredders	17.31
Percent Hydropsychinae of Trichoptera	00
Shannon H (log2)	3.03
Evenness	.68
Brillouin H	1.99
Simpson D	.17
EPT/Chironomidae	.02
CTQa	102.27
Percent Baetidae of Ephemeroptera	100
%Ephemeroptera	.32
%Plecoptera	.00
%Trichoptera	.00
%Coleoptera	.32
%Diptera	5.77
%Chironomidae	17.62
Multivoltine	42.95
Univoltine	56.41
Semivoltine	.64

Functional Feeding Groups	# taxa	% abundance
Predator	4	30.13
Collector-gatherer 1	0	21.15
Collector-filterer	2	25.00
Scraper	2	16.99
Shredder	1	.32

Estimated total number of organisms	3120

Jab sample.

Macroinvertebrate Taxonomic Data

Redwater River 2D, South of Circle

Taxon	#	%	BI	FFG
Lymnaeidae	1	0.31	6	SC
Physidae	137	43.08	8	SC
Cladocera	32	10.06	8	CF
Hyallela azteca	5	1.57	8	CG
TOTAL: MISC. TAXA	175	55.03		
Coenagrionidae: Enallagma	39	12.26	7	PR
TOTAL: ODONATA	39	12.26		
Callibaetis	1	0.31	9	CG
Caenis	4	1.26	7	CG
TOTAL: EPHEMEROPTERA	5	1.57		
Dytiscidae: Rhantus	4	1.26	5	PR
Haliplus	2	0.63	5	SH
TOTAL: COLEOPTERA	6	1.89		
Ceratopogonidae	9	2.83	6	PR
Pericoma	3	0.94	4	CG
Simulium	67	21.07	5	CF
TOTAL: DIPTERA	79	24.84		
Cricotopus Isocladius	8	2.52	7	CG
Dicrotendipes	2	0.63	8	CG
Micropsectra	1	0.31	4	CG
Paratanytarsus	3	0.94	6	UN
TOTAL: CHIRONOMIDAE	14	4.40		
GRAND TOTAL	318	100.00		

Aquatic Macroinvertebrate Data: Redwater River 2D, South of Circle. May 26, 1999.

Percent of sample used	20
Subsample size	318
Percent EPT	2
Taxa richness	16
EPT richness	2
Biotic Index	7.02
Percent dominant taxon	43.08
Percent dominance of five dominant taxa	89.30
Percent dominance of ten dominant taxa	96.85
Percent collectors (gatherers plus filterers)	38.67
Percent scrapers plus shredders	44.02
Percent Hydropsychinae of Trichoptera	00
Shannon H (log2)	2.53
Evenness	.63
Brillouin H	1.67
Simpson D	.26
EPT/Chironomidae	.36
CTQa	93.38
Percent Baetidae of Ephemeroptera	20
%Ephemeroptera	1.57
%Plecoptera	.00
%Trichoptera	.00
%Coleoptera	1.89
%Diptera	24.84
%Chironomidae	4.40
Multivoltine	13.60
Univoltine	84.51
Semivoltine	1.89

Functional Feeding Groups	# taxa	% abundance
Predator	3	16.35
Collector-gatherer	7	7.54
Collector-filterer	2	31.13
Scraper	2	43.39
Shredder	1	.63

Estimated total number of organisms Jab sample.	398

Macroinvertebrate Taxonomic Data

Redwater River 2F

Taxon	#	%	BI	FFG
Oligochaeta: Naididae	2	0.60	10	CG
Physidae	7	2.11	8	SC
Gyraulus	1	0.30	8	SC
Cladocera	2	0.60	8	CF
Copepoda	2	0.60	8	CG
Hyallela azteca	1	0.30	8	CG
Acari	13	3.92	5	PA
TOTAL: MISC. TAXA	28	8.43		
Coenagrionidae: Enallagma	16	4.82	7	PR
Lestidae: Lestes	1	0.30	9	PR
TOTAL: ODONATA	17	5.12		
Caenis	86	25.90	7	CG
TOTAL: EPHEMEROPTERA	86	25.90		
Corixidae	1	0.30	5	UN
TOTAL: HEMIPTERA	1	0.30		
Dubiraphia	10	3.01	6	SC
TOTAL: COLEOPTERA	10	3.01		
Ceratopogonidae	29	8.73	6	PR
Simulium	1	0.30	5	CF
TOTAL: DIPTERA	30	9.04		
Chironomus	3	0.90	10	CG
Cricotopus	1	0.30	7	CG
Cricotopus Isocladius	9	2.71	7	CG
Glyptotendipes	10	3.01	10	CG
Paratanytarsus	132	39.76	6	UN
Tanypus	1	0.30	10	PR
Tanytarsus	4	1.20	6	CF
TOTAL: CHIRONOMIDAE	160	48.19		
GRAND TOTAL	332	100.00		

Aquatic Macroinvertebrate Data: Redwater River 2F Below Circle STP. May 26, 1999.

Percent of sample used	10
Subsample size	332
Percent EPT	26
Taxa richness	21
EPT richness	1
Biotic Index	6.57
Percent dominant taxon	39.76
Percent dominance of five dominant taxa	83.13
Percent dominance of ten dominant taxa	95.17
Percent collectors (gatherers plus filterers)	36.42
Percent scrapers plus shredders	5.42
Percent Hydropsychinae of Trichoptera	00
Shannon H (log2)	2.74
Evenness	.62
Brillouin H	1.81
Simpson D	.24
EPT/Chironomidae	.54
CTQa	106.10
Percent Baetidae of Ephemeroptera	0
%Ephemeroptera	25.90
%Plecoptera	.00
%Trichoptera	.00
%Coleoptera	3.01
%Diptera	9.03
%Chironomidae	48.18
Multivoltine	41.27
Univoltine	55.42
Semivoltine	3.31

Functional Feeding Groups	# taxa	% abundance
Predator	4	14.15
Collector-gatherer	8	34.32
Collector-filterer	3	2.10
Scraper	3	5.42
Shredder	0	.00

Estimated total number of organisms	3320

20 jabs.

Macroinvertebrate Taxonomic Data

Redwater River 3A Below Pasture Creek

Taxon	#	%	BI	FFG
Oligochaeta: Naididae	1	0.34	10	CG
Physidae	14	4.73	8	SC
Gyraulus	2	0.68	8	SC
Hyallela azteca	5	1.69	8	CG
TOTAL: MISC. TAXA	22	7.43		
Caenis	49	16.55	7	CG
TOTAL: EPHEMEROPTERA	49	16.55		
Corixidae	1	0.34	5	UN
TOTAL: HEMIPTERA	1	0.34		
Hydroptila	1	0.34	6	CG
TOTAL: TRICHOPTERA	1	0.34		
Dubiraphia	4	1.35	6	SC
TOTAL: COLEOPTERA	4	1.35		
Ceratopogonidae	36	12.16	6	PR
Simulium	149	50.34	5	CF
TOTAL: DIPTERA	185	62.50		
Cricotopus Isocladius	16	5.41	7	CG
Dicrotendipes	1	0.34	8	CG
Polypedilum	1	0.34	6	CG
Pseudochironomus	12	4.05	5	CG
Tanytarsus	3	1.01	6	CF
Thienemannimyia	1	0.34	5	PR
TOTAL: CHIRONOMIDAE	34	11.49		
GRAND TOTAL	296	100.00		

Aquatic Macroinvertebrate Data: Redwater River 3A Below Pasture Creek. May 25, 1999.

Percent of sample used	25
Subsample size	296
Percent EPT	17
Taxa richness	16
EPT richness	2
Biotic Index	5.83
Percent dominant taxon	50.34
Percent dominance of five dominant taxa	89.19
Percent dominance of ten dominant taxa	97.97
Percent collectors (gatherers plus filterers)	80.41
Percent scrapers plus shredders	6.76
Percent Hydropsychinae of Trichoptera	00
Shannon H (log2)	2.39
Evenness	.60
Brillouin H	1.57
Simpson D	.30
EPT/Chironomidae	1.47
CTQa	105.50
Percent Baetidae of Ephemeroptera	0
%Ephemeroptera	16.55
%Plecoptera	.00
%Trichoptera	.34
%Coleoptera	1.35
%Diptera	62.50
%Chironomidae	11.49
Multivoltine	8.87
Univoltine	89.61
Semivoltine	1.52

Functional Feeding Groups	# taxa	% abundance
Predator	2	12.50
Collector-gatherer	8	29.06
Collector-filterer	2	51.35
Scraper	3	6.76
Shredder	0	.00

Estimated total number of organisms
20 jabs, 3 feet each. 90% bank, 10% riffle.

Macroinvertebrate Taxonomic Data

Redwater River 3D Nickwall Crossing

Taxon	#	%	BI	FFG
Nematoda	1	1.04	5	OM
Oligochaeta: Tubificidae	15	15.63	10	CG
TOTAL: MISC. TAXA	16	16.67		
Ophiogomphus	7	7.29	5	PR
Coenagrionidae: Enallagma	1	1.04	7	PR
TOTAL: ODONATA	8	8.33		
Caenis	17	17.71	7	CG
TOTAL: EPHEMEROPTERA	17	17.71		
Corixidae	25	26.04	5	UN
TOTAL: HEMIPTERA	25	26.04		
Cheumatopsyche	1	1.04	5	CF
Oecetis	2	2.08	8	PR
TOTAL: TRICHOPTERA	3	3.13		
Dubiraphia	10	10.42	6	SC
TOTAL: COLEOPTERA	10	10.42		
Simulium	11	11.46	5	CF
TOTAL: DIPTERA	11	11.46		
Cricotopus Isocladius	3	3.13	7	CG
Dicrotendipes	2	2.08	8	CG
Thienemannimyia	1	1.04	5	PR
TOTAL: CHIRONOMIDAE	6	6.25		
GRAND TOTAL	96	100.00		

Aquatic Macroinvertebrate Data: Redwater River 3D Nickwall Crossing. May 25, 1999.

Percent of sample used	100
Subsample size	96
Percent EPT	22
Taxa richness	13
EPT richness	3
Biotic Index	6.45
Percent dominant taxon	26.04
Percent dominance of five dominant taxa	81.26
Percent dominance of ten dominant taxa	96.88
Percent collectors (gatherers plus filterers)	51.05
Percent scrapers plus shredders	10.42
Percent Hydropsychinae of Trichoptera	33
Shannon H (log2)	3.00
Evenness	.81
Brillouin H	1.89
Simpson D	.15
EPT/Chironomidae	3.33
CTQa	100.77
Percent Baetidae of Ephemeroptera	0
%Ephemeroptera	17.71
%Plecoptera	.00
%Trichoptera	3.12
%Coleoptera	10.42
%Diptera	11.46
%Chironomidae	6.25
Multivoltine	5.99
Univoltine	68.49
Semivoltine	25.52

Functional Feeding Groups	# taxa	% abundance
Predator	4	11.45
Collector-gatherer	4	38.55
Collector-filterer	2	12.50
Scraper	1	10.42
Shredder	0	.00

Estimated total number of organisms 96

20 jabs. 3 ft. sweep. 70% banks, 30% riffle.

Aquatic Macroinvertebrate Data: East Fork Redwater River, Site 3EF. May 26, 1999.

Percent of sample used	90
Subsample size	298
Percent EPT	10
Taxa richness	12
EPT richness	1
Biotic Index	5.32
Percent dominant taxon	84.90
Percent dominance of five dominant taxa	97.32
Percent dominance of ten dominant taxa	99.35
Percent collectors (gatherers plus filterers)	97.33
Percent scrapers plus shredders	1.01
Percent Hydropsychinae of Trichoptera	00
Shannon H (log2)	.93
Evenness	.26
Brillouin H	.59
Simpson D	.73
EPT/Chironomidae	3.22
CTQa	105.00
Percent Baetidae of Ephemeroptera	0
%Ephemeroptera	9.73
%Plecoptera	.00
%Trichoptera	.00
%Coleoptera	.00
%Diptera	85.24
%Chironomidae	3.04
Multivoltine	2.27
Univoltine	97.73
Semivoltine	.00

Functional Feeding Groups	# taxa	% abundance
Predator	2	.68
Collector-gatherer	7	12.43
Collector-filterer	1	84.90
Scraper	1	1.01
Shredder	0	.00

Estimated total number of organisms	331
Estimated number collected per foot	11
Estimated number collected per minute	331

Macroinvertebrate Taxonomic Data

East Fork Redwater River 3EF

Taxon	#	%	BI	FFG
Physidae	3	1.01	8	SC
Hyallela azteca	2	0.67	8	CG
TOTAL: MISC. TAXA	5	1.68		
Coenagrionidae: Enallagma	1	0.34	7	PR
TOTAL: ODONATA	1	0.34		
Caenis	29	9.73	7	CG
TOTAL: EPHEMEROPTERA	29	9.73		
Ceratopogonidae	1	0.34	6	PR
Simulium	253	84.90	5	CF
TOTAL: DIPTERA	254	85.23		
Chironomus	1	0.34	10	CG
Cricotopus Isocladius	2	0.67	7	CG
Dicrotendipes	1	0.34	8	CG
Glyptotendipes	1	0.34	10	CG
Paratanytarsus	3	1.01	6	UN
Pseudochironomus	1	0.34	5	CG
TOTAL: CHIRONOMIDAE	9	3.02		
GRAND TOTAL	298	100.00		

Macroinvertebrate Taxonomic Data
Redwater River 3F

Taxon	#	%	BI	FFG
Oligochaeta: Naididae	3	1.14	10	CG
Physidae	1	0.38	8	SC
Gyraulus	1	0.38	8	SC
Hyallela azteca	2	0.76	8	CG
Acari	6	2.28	5	PA
TOTAL: MISC. TAXA	13	4.94		
Coenagrionidae: Enallagma	21	7.98	7	PR
TOTAL: ODONATA	21	7.98		
Caenis	95	36.12	7	CG
Ephemeridae: Hexagenia	8	3.04	4	CG
TOTAL: EPHEMEROPTERA	103	39.16		
Corixidae	81	30.80	5	UN
TOTAL: HEMIPTERA	81	30.80		
Oecetis	5	1.90	8	PR
Polycentropus	1	0.38	6	PR
TOTAL: TRICHOPTERA	6	2.28		
Dubiraphia	12	4.56	6	SC
TOTAL: COLEOPTERA	12	4.56		
Simulium	2	0.76	5	CF
TOTAL: DIPTERA	2	0.76		
Cricotopus Isocladius	1	0.38	7	CG
Dicrotendipes	1	0.38	8	CG
Larsia	1	0.38	6	PR
Paratanytarsus	8	3.04	6	UN
Pseudochironomus	14	5.32	5	CG
TOTAL: CHIRONOMIDAE	25	9.51		
GRAND TOTAL	263	100.00		

Aquatic Macroinvertebrate Data: Redwater River Site 3F. May 26, 1999.

Percent of sample used	100
Subsample size	263
Percent EPT	41
Taxa richness	18
EPT richness	4
Biotic Index	6.11
Percent dominant taxon	36.12
Percent dominance of five dominant taxa	84.78
Percent dominance of ten dominant taxa	96.18
Percent collectors (gatherers plus filterers)	47.90
Percent scrapers plus shredders	5.32
Percent Hydropsychinae of Trichoptera	00
Shannon H (log2)	2.68
Evenness	.64
Brillouin H	1.75
Simpson D	.24
EPT/Chironomidae	4.36
CTQa	96.78
Percent Baetidae of Ephemeroptera	0
%Ephemeroptera	39.16
%Plecoptera	.00
%Trichoptera	2.28
%Coleoptera	4.56
%Diptera	.76
%Chironomidae	9.50
Multivoltine	9.60
Univoltine	83.75
Semivoltine	6.65

Functional Feeding Groups	# taxa	% abundance
Predator	4	10.64
Collector-gatherer	7	47.14
Collector-filterer	1	.76
Scraper	3	5.32
Shredder	0	.00

Estimated total number of organisms	263
Estimated number collected per foot	9
Estimated number collected per minute	263

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BIOASSESSMENT OF THE TETON RIVER AND THE NORTH FORK OF THE TETON RIVER, TETON AND CHOTEAU COUNTIES, MONTANA

JULY AND AUGUST, 1998

DRAFT

PREPARED FOR
The Montana Department of Environmental Quality
Helena, Montana

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FEBRUARY, 1999

INTRODUCTION

Benthic assemblages are aptly applied to aquatic bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970.) Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations. Multimetric approaches to bioassessment use attributes of the assemblage in an integrated way to measure overall biotic condition.

The additive multimetric approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "… an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment. (Fore et al. 1995). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998). The first element is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied must be done, to assist in the interpretation of metric outcomes.

This report summarizes data collected in 1998 from the Teton River and its North Fork, by means of a multimetric method, an adaptation of the U.S. EPA's Rapid Bioassessment Protocols (RBP III) (Plafkin et al. 1989). Macroinvertebrates were collected at eight sites from the mouth of the river to the North Fork, encompassing a great deal of the length of the river, and extending through two ecoregions. The lower river passes through the Plains ecoregions, and the upper river and the North Fork site are located in the Montana Valleys and Foothill Prairies (MVFP) ecoregion.

Metric selection for this study is partly based on the recommendations found in the standard operating procedures for macroinvertebrate sampling and analysis of the Montana Department of Environmental Quality (MT DEQ) (Bukantis 1998). Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat parameters and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Assurance of the validity of association between habitat parameters and biotic metrics is particularly compelling in the two ecoregions through which the Teton River flows, since impairment of the biotic health of rivers in these two regions is generally the result of non-point sources. Agricultural activities, including cattle grazing and flow alteration, are predominant causes of stream degradation. The benthic assemblages of the Plains ecoregions and the performance of bioassessment metrics have not yet been examined thoroughly enough to determine whether or not the individual metrics or their integrated scores can discriminate impaired conditions from good biotic health. Bollman (1998) has recently studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics specific to that ecoregion, which has been shown to be sensitive to impairment, related to habitat assessment parameters, and consistent over replicated samples.

Habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by metals, other toxicants, or high levels of organic and/or nutrient pollution might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment in an oligotrophic setting. Habitat assessment data is even more important in the Plains ecoregions, where the relationships between habitat variables and benthic community characteristics remain largely unknown.

METHODS

Aquatic macroinvertebrates were sampled by personnel of the Montana Department of Environmental Quality (MT DEQ) from eight sites on the Teton River and its North Fork. Three sites lay in the Montana Valleys and Foothill Prairies ecoregion and five sites lay in the Plains ecoregions. Sampling sites were numbered and described as shown in Table 1.

Table 1. Identification information for macroinvertebrate samples from the Teton River, July and August, 1998. Sites are numbered from the most downstream location to the most upstream location.

ecoregion	DEQ site number	site location	date sampled
Plains	8B	Teton River at Loma, above bridge near mouth	8/4/98
Plains	10B	Teton River at Dent Bridge	8/4/98
Plains	11B	Teton River at Kerr Bridge, at USGS gauging station	8/4/98
Plains	12B	Teton River at I-15, below rest stop	8/5/98
Plains	14B	Teton River at Highway 221 bridge	8/5/98
Montana Valleys and Foothill Prairies	Teton 2	Teton River at Breen's Ranch, above diversion	7/23/98
Montana Valleys and Foothill Prairies	Teton 1	Teton River at gauge station at bridge, below confluence of North and South Forks	7/20/98
Montana Valleys and Foothill Prairies	N. Fk. Teton 1	North Fork Teton River near mouth on Abbott's land	7/22/98

In addition to macroinvertebrate sample collection, habitat quality was visually evaluated at each site and reported by means of the habitat assessment protocols recommended by Bukantis (1998). Macroinvertebrate samples and associated habitat data were delivered to Rhithron Biological Associates, Missoula, Montana, for laboratory and data analyses.

In the laboratory, the RBP III sorting method was used to obtain subsamples of 300 (+/- 10%) organisms from each sample. Community structure, function, and sensitivity to impact were characterized for each subsample using two methods prescribed by MT DEQ (Bukantis 1998) for Plains ecoregions sites, and three methods for Montana Valleys and Foothill Prairies sites. First, Plains sites' (sites 8B, 10B, 11B, 12B, and 14B) data were evaluated using the Plains ecoregions reference. In this approach, benthic community attributes were compared to reference criteria established by MT DEQ for streams of both Plains ecoregions in the State, namely the Northwestern Great Plains and the Northwestern Glaciated Plains (Omernik et al. 1997). The ecoregional reference approach for the Plains ecoregions uses ten metrics (Bukantis 1998). In the second approach, an internal reference was established for Plains sites on the Teton River: a reference value for each of the ten metrics was established based on the performance of the metrics at Plains sites. The best value, if appropriate for the analysis, was chosen as the point of comparison for each metric used. In some cases, best values represented unrealistic reference values; in such cases, more appropriate actual values were chosen. Scoring criteria for the internal reference followed the system devised by Bollman (1996). Similar approaches were used for sites located in the Montana Valleys and Foothill Prairies ecoregion (Teton 2, Teton 1 and N.Fk. Teton 1): data were compared to the appropriate ecoregional reference criteria recommended by Bukantis (1998) and then to the internal reference established specifically for the Teton River sites located within the valleys and foothill prairies. The ecoregional reference and internal reference metric battery for these sites is comprised of eight metrics. Finally, for these three sites, a revised metric battery and scoring criteria, developed for the Montana Valleys and Foothill Prairies by Bollman (1998) and utilizing six metrics, was applied.

For all of these analyses, actual metric values were compared to the appropriate reference values to obtain metric scores. Biointegrity was estimated as the combined score for all metrics expressed as a percentage of the maximum possible score. As a result of the alternative approaches used here, two bioassessment scores are reported for the sites in the Plains ecoregions, and three are reported for the sites in the Montana Valleys and Foothill Prairies ecoregion.

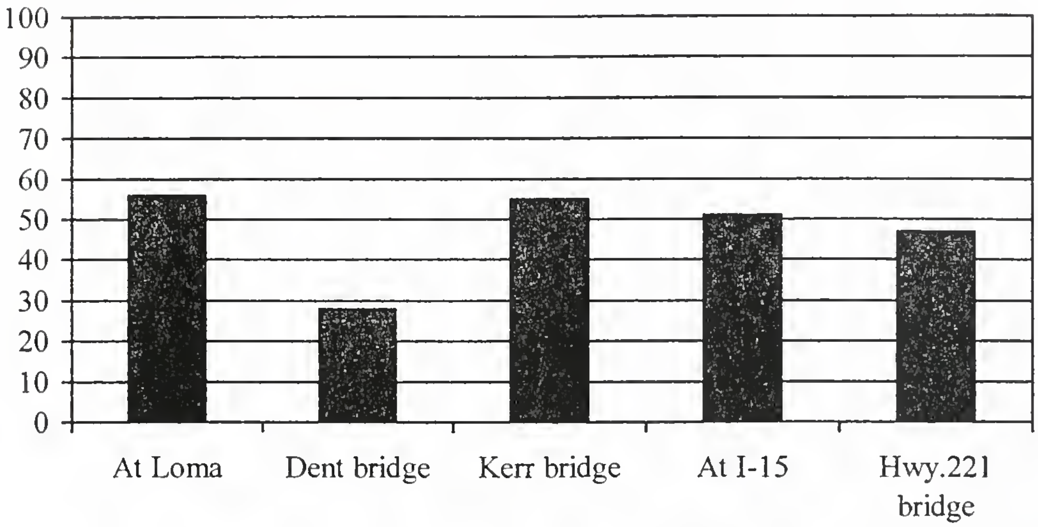
RESULTS

Habitat assessments

I. Plains ecoregions sites

Figure 1 compares habitat assessment results for the five Plains ecoregions sites. Stream morphology was reported to be predominantly composed of glide/pool conditions at the four lowermost sites; riffle/run predominance was reported at the Highway 221 bridge site, so two different habitat assessment protocols were used for evaluating these sites. Breakdown of total scores into the ten evaluated parameters is presented in Tables 2a and 2b.

Figure 1. Total habitat assessment scores for five Plains ecoregions sites on the Teton River, August 1998.



Marginal habitat conditions were noted at Dent bridge, which received the lowest total habitat assessment score of the sites studied. Numerous factors were perceived to contribute to degraded conditions here, including major sediment deposition and monotonous benthic substrate in both runs and pools, likely consequences of channel downcutting and its resultant vertical, unvegetated and unstable streambanks. Together with the apparent lack of instream habitat, extensive large-scale channel alteration was reported as well, with associated changes to sinuosity. Riparian vegetative influences to the benthic community appeared to be largely lost due to isolation of the channel from the nearstream vegetated zone, attributable to downcutting, which in turn may be a result of channelization. Instream flow was also reported to be moderately compromised, perhaps by upstream diversions.

Sites at Loma and at Kerr bridge were noted to have sub-optimal habitat conditions. At Loma, near the river's mouth, instream habitat appeared to be limited in runs, where packed sand and gravel predominated, but seemed to be optimal in pools. However, pools occurred only infrequently. These observations are consistent with the major sediment deposition also reported at this site. Mild to moderately eroded streambanks with obvious disruption to vegetation are potential sources of the sediment. Flow conditions at this site were perceived to be sub-optimal, with recent rain contributions. Some channelization due to the placement of the highway was present upstream of the sample area, but was not considered recent. The riparian vegetative zone width was noted to be optimal, but downcutting of the stream channel may isolate the benthos from riparian influences.

Table 2. Stream and riparian habitat assessment: Teton River, Plains ecoregions sites. August 1998. Protocol for glide/pool prevalence was used for lower four sites, and protocol for riffle/run prevalence was used for the site at Highway 221 bridge (Bukantis 1998).

Max. score	**Parameter**	**At Loma**	**Dent bridge**	**Kerr bridge**	**At I-15**	**Max. possible score**	**Parameter**	**At Hwy. 221 bridge**
20	bottom substrate/cover	6	7	12	7	**10**	riffle development	9
20	pool substrate character	16	7	8	12	**10**	substrate development	2
20	pool variability	5	3	9	8	**20**	embeddedness	3
20	channel alteration	15	3	10	10	**20**	channel alteration	12
20	sediment deposition	6	8	16	10	**20**	sediment deposition	3
20	channel sinuosity	10	7	6	10	**20**	flow status	16
20	flow status	15	6	12	12	**10 / 10**	bank stability (right/left)	3 / 3
10 / 10	bank vegetative protection (left / right)	5 / 5	2 / 3	7 / 8	7 / 6	**10 / 10**	bank vegetative cover (right/left)	3 / 3
10 / 10	bank stability (left / right)	2 / 8	5 / 1	7 / 5	5 / 4	**10 / 10**	riparian width (right/left)	9 / 9
10 / 10	riparian vegetative zone width (left / right)	9 / 9	1 / 3	5 / 5	8 / 3			
200	**TOTAL:**	111	56	110	102	**160**	**TOTAL:**	75
	PERCENT OF MAXIMUM:	56	28	55	51		**PERCENT OF MAXIMUM:**	47
	CONDITION[1]:	SUB-OPTIMAL	MARGINAL	SUB-OPTIMAL	SUB-OPTIMAL		**CONDITION[1]:**	MARGINAL

1. Condition categories: Optimal > 81% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%.

At Kerr bridge, fine sediment deposition was perceived to be less of a problem than at the other two sites; particle size classes were noted to be more variable than at Loma or at Dent bridge. Pool variability and substrate received marginal scores, however. Bank stability was reported to be better here than at lower sites, with sub-optimal vegetative protection. Channelization was perceived to limit the potential of the river at this site, and possibly resulted in the observed channel downcutting which isolated the riparian vegetative zone from the stream. Instream water retention received a sub-optimal score.

At the Interstate highway, the patterns of habitat degradation were perceived to be similar to those noted at downstream sites; downcutting, perhaps a result of extensive channel alteration, major fine sediment deposition and monotonous benthic substrate were reported as the predominant characteristics of the river at this site. Riparian influence was limited to stream sides on inside of meanders, with moderately unstable vertical banks isolating riparian vegetation from the channel on outside curves. Overall habitat score for the site gave it a sub-optimal classification.

The site at the Highway 221 bridge was the only Plains site with riffle/run prevalence; habitat was therefore evaluated differently here than at the other Plains ecoregions sites. Despite this, similar impacts were reported. Channel downcutting, moderately unstable vertical streambanks with disrupted vegetative protection and severe sediment deposition characterized habitat at this site. Wide zones of riparian vegetation were noted to be present beyond the eroding streambanks. Habitat was judged marginal here.

II. Montana Valleys and Foothill Prairies sites

Figure 2 compares habitat assessment results for the three Montana Valleys and Foothill Prairies ecoregion sites. Stream morphology was reported to be predominantly composed of riffle/run conditions at these sites. Breakdown of total scores into the nine evaluated parameters is presented in Table 3.

At sites above Choteau, habitat assessment scores improved in an upstream direction. Marginal conditions at Breen's were attributable to poor streambank stability, associated with a loss of both vegetative protection and riparian zone influence due to downcutting. On-going channel alteration and heavy equipment operation with the purpose of maintaining berms to separate the channel from an irrigation ditch may be a factor in the addition of heavy deposits of gravel and cobble into the channel, practically obliterating pools. Marginal flow conditions were reported to worsen below the irrigation diversion.

Farther upstream, the site at the gauging station was judged to have sub-optimal habitat conditions. Instream parameters were scored optimally, while larger-scale channel morphology was perceived to be of marginal quality, with an essentially straight channel capable of scouring flows resulting in a loss of smaller size classes of substrate particles, including spawning gravels for fish. Marginal flow conditions were noted, with recent exposure of substrate stranding some glossosomatid caddisflies. Bank stability was perceived to be mildly-to-moderately unstable, with loss of vegetative cover.

Optimal conditions were reported at the most upstream site, on the North Fork of the Teton River. Some sediment deposition was noted, but the bars thus formed were being colonized by riparian vegetation. Mild bank vegetation disruption was noted, and one side was perceived to have sub-optimal riparian vegetative width.

Figure 2. Total habitat assessment scores for three Montana Valleys and Foothill Prairies ecoregion sites on the Teton River, July 1998.

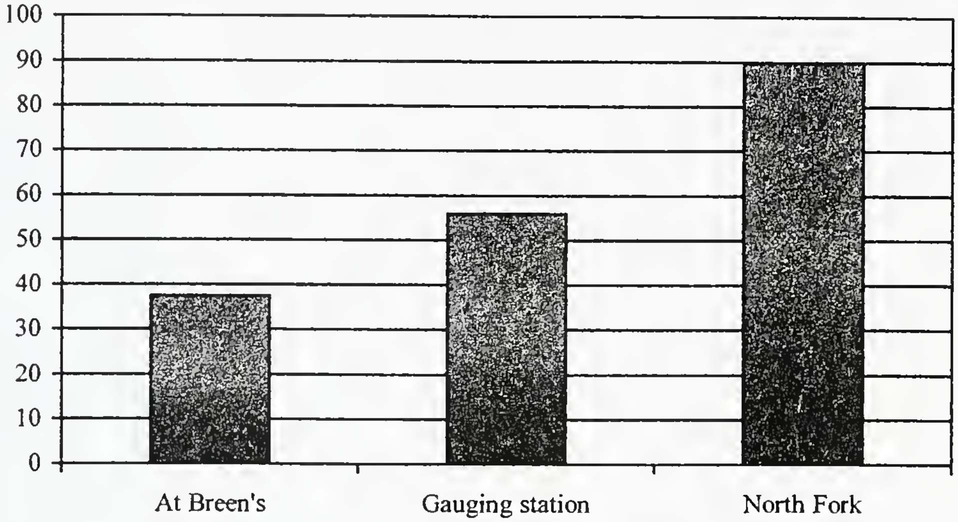


Table 3. Stream and riparian habitat assessment: Teton River, Montana Valleys and Foothill Prairies ecoregion sites. July 1998. Protocol for riffle/run prevalence was used (Bukantis 1998).

Max. possible score	Parameter	At Breen's	At gauging station	North Fork
10	riffle development	9	10	10
10	substrate development	8	9	10
20	embeddedness	16	20	20
20	channel alteration	6	9	19
20	sediment deposition	3	6	15
20	flow status	6	7	17
20	bank stability (right/left)	2 / 2	6 / 2	9 / 9
10 / 10	bank vegetative cover (right/left)	2 / 2	3 / 3	8 / 9
10 / 10	riparian width (right/left)	2 / 2	8 / 3	8 / 10
160	**TOTAL:**	60	89	144
	PERCENT OF MAXIMUM:	37.5	56	90
	CONDITION[1]:	**MARGINAL**	**SUB-OPTIMAL**	**OPTIMAL**

1. Condition categories: Optimal > 81% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%.

Bioassessments

Macroinvertebrate taxa lists, metric results and other information for each sample are given in the Appendix.

1. Plains ecoregions sites: The Plains ecoregions reference

Figure 3 compares total bioassessment scores from integrated and summed metrics using the Plains ecoregional reference scoring criteria. Table 4 summarizes this method and criteria. Breakdown of values and scores for each metric is presented in Table 5.

Figure 3. Total bioassessment score based on the Plains ecoregional reference. Teton River sites below Choteau, Montana. August 1998.

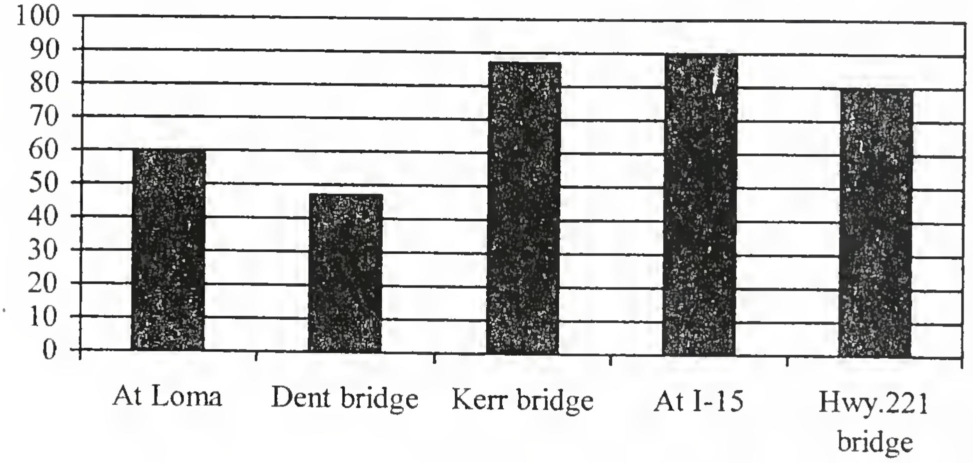


Table 4. Metrics and scoring criteria for Plains ecoregions streams (Bukantis 1998).

metric	**Scoring Criteria** 3	2	1	0
Taxa richness	>24	24 - 18	18 - 12	<12
EPT richness	>8	8 - 6	5 - 3	<3
Biotic index	<5	5 - 6	6 - 7	>7
% dominant taxon	<30	30 - 45	45 - 60	>60
% collector (gatherers + filterers)	<60	60 - 80	80 - 95	>95
% EPT	>50	50 - 30	30 - 10	<10
Shannon diversity	>3.0	3.0 – 2.4	2.4 – 1.8	<1.8
% scrapers + shredders	>30	30 - 15	15 - 3	<3
Predator taxa richness	>5	4 - 5	3 - 4	<3
% multivoltine	<40	40 - 60	60 - 80	>80

Table 5. Metric values, scoring and bioassessments based on Plains ecoregions reference. Teton River. August 1998.

metric	*At Loma*	*Dent bridge*	*Kerr bridge*	*At I-15*	*Hwy.221 bridge*
Taxa richness	20	11	21	26	24
EPT richness	12	5	13	18	12
Biotic index	2.58	4.35	4.01	4.58	4.43
% dominant taxon	81	39	22	26	29
% collector (G+FF)	95	94	66	72	79
% EPT	93	58	85	88	83
Shannon diversity	1.36	2.86	3.52	3.38	3.21
% scraper + shredder	1	0	18	24	14
Predator taxa richness	6	2	5	5	3
% multivoltine	3	16	10	11	18
			scores		
Taxa richness	2	0	2	3	2
EPT richness	3	1	3	3	3
Biotic index	3	3	3	3	3
% dominant taxon	0	2	3	3	3
% collector (G+FF)	1	1	2	2	2
% EPT	3	3	3	3	3
Shannon diversity	0	1	3	3	3
% scraper + shredder	0	0	2	2	1
Predator taxa richness	3	0	2	2	1
% multivoltine	3	3	3	3	3
Total score (max.=30)	18	14	26	27	24
percent of maximum	60	47	87	90	80
classification [1]	**SLI**	**MOD**	**NON**	**NON**	**SLI**
use support [2]	**PART**	**PART**	**FULL**	**FULL**	**FULL**

[1] See Table 6b. NON = nonimpaired, SLI = slightly impaired, MOD = moderately impaired, SEV = severely impaired.

[2] See Table 6a. FULL = full support, PARTIAL = partial support, NON! = non-support.

Criteria for the assignment of impairment classifications and use support designations are shown in Table 6. These same criteria are applied to total metric scores regardless of the bioassessment protocol used.

The Teton River site below the interstate highway (I-15) received the highest bioassessment score of any of the five Plains ecoregions sites, and was classified as non-impaired. Compared to the Plains ecoregions reference, non-impaired biotic health was also assessed at the Kerr bridge site. Both of these sites were designated as fully supporting their use categories. Slight impairment was scored at both the Loma site, which was the lowermost of the Plains ecoregions sites, and at the Highway 221 bridge, which was the uppermost Plains site. While the use support designation at Loma was partial, it was full at the uppermost site. The site at Dent bridge received the lowest score of the five Plains sites, with scores indicating moderate impairment and partial use support, compared to ecoregional reference conditions.

Table 6a. Criteria for the assignment of support classifications / standards violation thresholds (from Bukantis, 1998)

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table 6b. Criteria for the assignment of impairment classifications (from Plafkin et al. 1989).

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

2. Plains ecoregions sites: The Teton River internal reference

When compared only with each other by means of the internal reference, the Plains ecoregions streams in this study generally receive scores similar to those they received when compared to streams across the Plains ecoregions. As before, the highest total bioassessment score was assigned to the site at the interstate highway, which was considered non-impaired and fully supporting its use classification, and the lowest score was assigned to the Dent bridge site, which was considered moderately impaired and partially use-supporting. Only the uppermost site of the five, at the Highway 221 bridge, received a different impairment classification; using the internal reference, this site was classified as non-impaired. Figure 4 compares total bioassessment scores of the Plains sites when metric values were compared to the internal reference. Table 6 shows the values for the Teton River internal reference and its scoring criteria. Table 7 shows the scoring and bioassessments for benthic assemblages of the Plains sites.

The Teton River internal reference was, in some regards, a more stringent assessment of biotic health for the Plains ecoregions sites on the river. Some important metrics, such as taxa richness, EPT richness and percent multivoltine taxa were "set" higher as internal reference criteria than they were in the MT DEQ Plains ecoregions criteria. This suggests that the Teton River has excellent potential for biotic health if habitat and water quality degradation were to be controlled or reversed.

Figure 4. Total bioassessment scores based on Teton River internal reference. Plains ecoregions sites. August 1998.

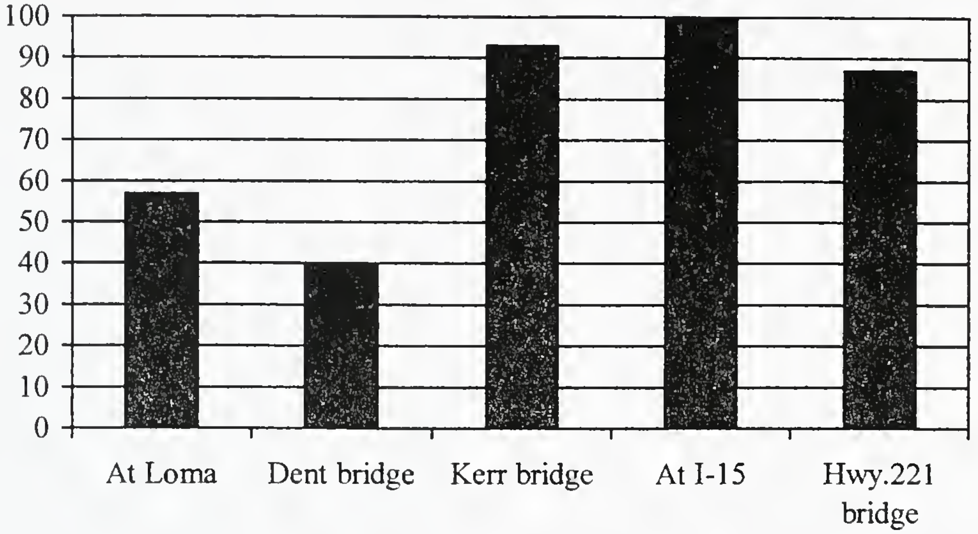


Table 7. Internal reference values and tentative criteria for assigning scores to metrics based on percent comparability to reference values (from Bollman 1997).

metric	*Teton River reference 1998*[1]	*Scoring criteria*[2]				
		3	*2*	*1*	*0*	*
Taxa richness	26	>85%	85-75%	75-60%	<60%	a
EPT richness	18	>80%	80-50%	50-35%	<35%	a
Biotic index	4.24	>90%	90-80%	80-70%	<70%	b
% dominant taxon	26	>75%	75-60%	60-50%	<50%	b
% collector (G+FF)	66	>90%	90-75%	75-60%	<60%	b
% EPT	88	>85%	85-75%	75-40%	<40%	a
Shannon diversity	3.52	>90%	90-80%	80-70%	<70%	a
% scrapers + shredders	24	>70%	70-50%	50-25%	<25%	a
Predator taxa richness	5	>60%	60-50%	50-40%	<40%	a
% multivoltine	10	>35%	35-25%	25-15%	<15%	b

1. Internal reference values are the "best" appropriate values among those calculated from 1998 Teton River, Plains ecoregions sites.
2. Scoring criteria are based on an analysis of metric ranges for 17 Plains ecoregions sites in four years of data collected by the Montana Department of Environmental Quality.

*a = score is ratio of study site value to reference value x 100
*b = score is ratio of reference value to study site value x 100

Table 8. Metric scores and bioassessments based on Teton River internal reference criteria. Plains ecoregions sites. August 1998.

metric	*At Loma*	*Dent bridge*	*Kerr bridge*	*At I-15*	*Hwy.221 bridge*
Taxa richness	2	0	2	3	3
EPT richness	2	0	2	3	2
Biotic index	3	3	3	3	3
% dominant taxon	0	2	3	3	3
% collector (G+FF)	1	1	3	3	2
% EPT	3	1	3	3	3
Shannon diversity	0	2	3	3	3
% scraper + shredder	0	0	3	3	2
Predator taxa richness	3	1	3	3	2
% multivoltine	3	3	3	3	3
Total score (max.=30)	17	13	28	30	26
percent of maximum	57	43	93	100	87
classification [1]	**SLI**	**MOD**	**NON**	**NON**	**NON**
use support [2]	**PART**	**PART**	**FULL**	**FULL**	**FULL**

[1] See Table 6b. NON = nonimpaired, SLI = slightly impaired, MOD = moderately impaired, SEV = severely impaired.

[2] See Table 6a. FULL = full support, PARTIAL = partial support, NON! = non-support.

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3. Montana Valleys and Foothill Prairies sites: The MVFP ecoregion reference

Figure 5 compares total bioassessment scores from integrated and summed metrics using the Montana Valleys and Foothill Prairies ecoregional reference scoring criteria. Table 9 summarizes this method and criteria. Breakdown of values and scores for each metric is presented in Table 10.

The uppermost site, on the North Fork of the Teton River, received the highest bioassessment score and was classified as non-impaired. Compared to streams around the Montana Valleys and Foothill Prairies ecoregion, the site at the gauging station was slightly impaired. The bioassessment score at the North Fork site indicated full support of uses, while the site at the gauging station was partially supporting of uses. The lowermost of the three MVFP sites, at Breen's, was also slightly impaired, and was designated as partially supporting of uses.

Figure 5. Total bioassessment scores based on the ecoregional reference. Montana Valleys and Foothill Praires sites on the Teton River and its North Fork. July 1998.

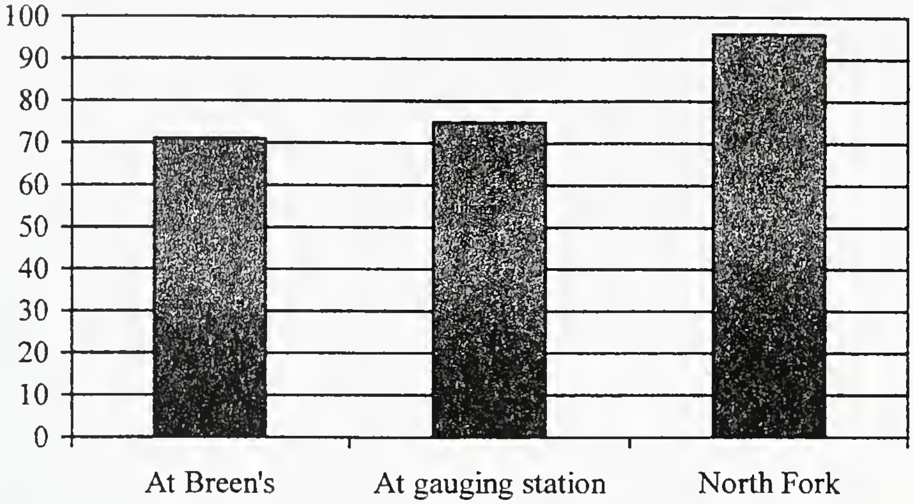


Table 9. Montana Valleys and Foothill Prairies ecoregion reference and scoring criteria. (Bukantis 1998.)

	Score			
Metric	**3**	**2**	**1**	**0**
Taxa richness	>28	28-21	21-14	<14
EPT richness	>14	14-13	12-11	<11
Biotic Index	<4	4-5	5-6	>6
% dominant taxon	<30	30-40	40-50	>50
% collectors (G + FF)	<60	60-75	75-90	>90
% scrapers + shredders	>30	30-20	20-10	<10
% EPT	>60	60-45	45-30	<30
% Hydropsychinae of Trichoptera	<75	75-85	85-95	>95

Table 10. Metric values, scoring and bioassessments based on Montana Valleys and Foothill Prairies ecoregion reference. Teton River. July 1998.

metric	*At Breen's*	*Gauging station*	*North Fork*
Taxa richness	41	16	27
EPT richness	18	10	16
Biotic index	4.48	1.55	1.46
% dominant taxon	17	39	28
% collector (G+FF)	66	35	35
% scraper + shredder	8	63	62
% EPT	35	78	79
% H of T	15	0	0
		scores	
Taxa richness	3	1	2
EPT richness	3	0	3
Biotic index	2	3	3
% dominant taxon	3	2	3
% collector (G+FF)	2	3	3
% scraper + shredder	0	3	3
% EPT	1	3	3
% H of T	3	3	3
Total score (max.=24)	17	18	23
percent of maximum	71	75	96
classification [1]	**SLI**	**SLI**	**NON**
use support [2]	**PART**	**PART**	**FULL**

[1] See Table 6b. NON = nonimpaired, SLI = slightly impaired, MOD = moderately impaired, SEV = severely impaired.

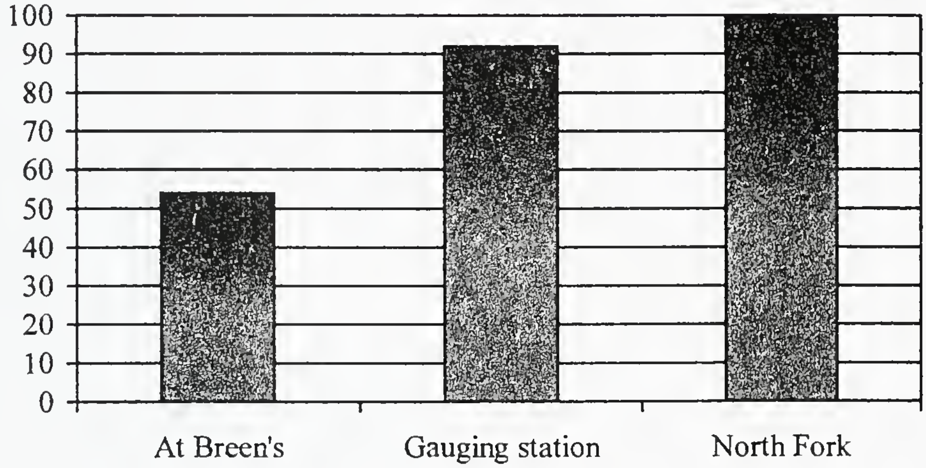
[2] See Table 6a. FULL = full support, PARTIAL = partial support, NON! = non-support.

4. Montana Valleys and Foothill Prairies ecoregion sites: The Teton River internal reference

Figure 6 compares total bioassessment scores for the Teton River sites in the MVFP ecoregion when scored using an internal reference approach. Table 11 shows the values for the Teton River internal reference and its scoring criteria. Table 12 gives the scoring and bioassessments for benthic assemblages of the three MVFP sites based on the internal reference.

The same pattern of improvement in total bioassessment score is apparent when the sites are compared only with each other as when the sites are compared with streams of the entire MVFP ecoregion; there is an apparent improvement in biotic condition in each consecutive upstream location. However, the internal reference approach accentuates the differences among the sites. The benthic assemblage at Breen's still exhibited slight impairment to biotic health, yet the total score was much less than it was using the ecoregion criteria, and compared to the non-impaired assemblage sampled at the North Fork site, the assemblage at Breen's was considerably more impaired. In contrast, the gauging station site received a higher score using the internal reference criteria, and was rated non-impaired, with a full use support designation. The North Fork site received maximal scores for all metrics in the MT DEQ MVFP battery.

Figure 6. Total bioassessment score based on Teton River internal reference for Montana Valleys and Foothill Prairies sites. Teton River. July 1998.



Generally, the internal reference criteria for these three sites on the Teton River and its North Fork were more stringent criteria than those established by the State for Montana Valleys and Foothill Prairies streams. Internal reference values for EPT richness, percent EPT and, especially, the biotic index set quite high standards for the upper reaches of the Teton River, and suggest that it has good potential for biotic health were habitat degradation to be controlled or reversed.

Table 11. Internal reference values and criteria for assigning scores to metrics based on percent comparability to reference values (adapted from McGuire 1995)

metric	*Teton River internal reference*	*scoring criteria*				
		3	*2*	*1*	*0*	
Taxa richness	27	> 80%	80-60%	60-40%	< 40%	a
EPT richness	18	> 85%	85-70%	70-50%	< 50%	a
Biotic index	1.55	> 90%	90-80%	80-70%	< 70%	b
% dominant taxon	28	> 60%	60-45%	45-30%	< 30%	b
%collector (G+FF)	35	> 90%	90-80%	80-70%	< 70%	b
% scraper + Shredder	63	> 80%	80-60%	60-40%	< 40%	a
% EPT	0	> 75%	75-50%	50-25%	< 25%	a
% Hydropsychinae of Trichoptera	79	< 50%	50-70%	70-90%	> 90%	c

[1] 1998 Internal reference values are the "best" appropriate values among those calculated from 1998 data.

* a = score is ratio of study site to reference x 100.

* b = score is ratio of reference to study site x 100.

* c = score is based on the actual value, not a percentage of reference.

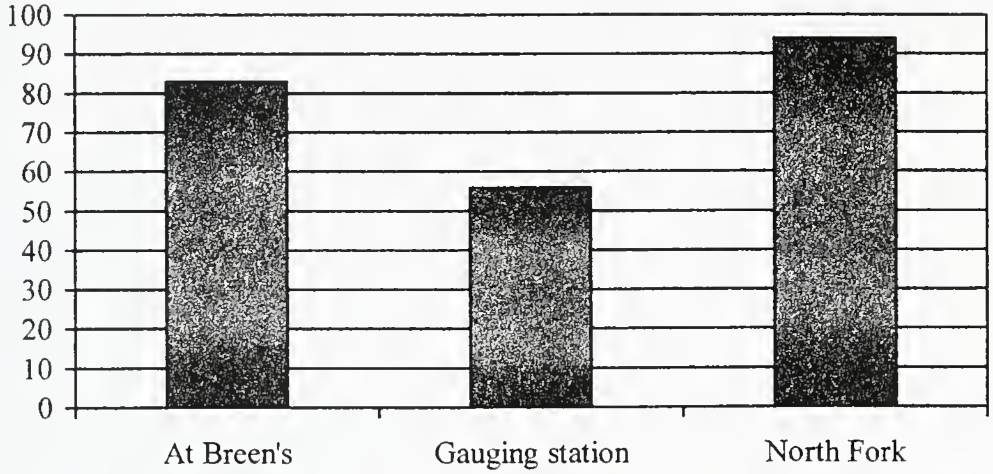
Table 12. Metric scores and bioassessments based on Teton River internal reference criteria. Montana Valleys and Foothill Prairies ecoregion sites. July 1998.

metric	*At Breen's*	*Gauging station*	*North Fork*
Taxa richness	41	16	27
EPT richness	18	10	16
Biotic index	4.48	1.55	1.46
% dominant taxon	17	39	28
% collector (G+FF)	66	35	35
% scraper + shredder	8	63	62
% EPT	35	78	79
% H of T	15	0	0
Total score (max.=24)	17	18	23
percent of maximum	71	75	96
classification[1]	**SLI**	**SLI**	**NON**
use support[2]	**PART**	**PART**	**FULL**

4. Montana Valleys and Foothill Prairies sites: A revised bioassessment method

Figure 7 compares total bioassessment scores for the three sites on the East Boulder River when a revised metric battery, proposed by Bollman (1998) is used. Table 13 summarizes this method and its criteria. Table 14 gives a breakdown of the scores for individual metrics and bioassessments for each site.

Figure 7. Total bioassessment scores based on a revised method for Montana Valleys and Foothill Prairies ecoregion streams. Teton River sites. July 1998.



Use of the revised method gave the same results as the other two bioassessment methods for the evaluation of the benthic assemblage sampled at the North Fork site; it was scored as non-impaired. However, the two lower MVFP sites on the Teton River were scored quite differently: the site at Breen's was non-impaired, with full use support designation, according to the criteria applied in this method. The site at the gauging station had the most impairment to biotic health of the three sites judging by these criteria. The score at this site indicated slight impairment, and partial use support designation.

Table 13. Montana Valleys and Foothill Prairies ecoregion reference and scoring criteria, revised method. (Bollman 1998.)

metric	*Scoring criteria*			
	3	2	1	0
Ephemeroptera taxa richness	> 5	5 - 4	3 – 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	<2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 - 5	5.01 - 10	10.01 - 25	> 25
Percent tolerant taxa	0 - 5	5.01 - 10	10.01 - 35	> 35

Table 10. Metric values, scoring and bioassessments based on Montana Valleys and Foothill Prairies ecoregion reference. Teton River. July 1998.

metric	*At Breen's*	*Gauging station*	*North Fork*
Ephemeroptera taxa richness	6	7	9
Plecoptera taxa richness	5	1	4
Trichoptera taxa richness	7	2	5
Sensitive taxa richness	1	1	5
Percent filterers	4	15.5	9
Percent tolerant taxa	8.3	0	0.3
		scores	
Ephemeroptera taxa richness	3	3	3
Plecoptera taxa richness	3	1	3
Trichoptera taxa richness	3	1	3
Sensitive taxa richness	1	1	3
Percent filterers	3	1	2
Percent tolerant taxa	2	3	3
Total score (max.=18)	15	10	17
percent of maximum	83	56	94
classification [1]	**NON**	**SLI**	**NON**
use support [2]	**FULL**	**PART**	**FULL**

[1] See Table 6b. NON = nonimpaired, SLI = slightly impaired, MOD = moderately impaired, SEV = severely impaired.

[2] See Table 6a. FULL = full support, PARTIAL = partial support, NON! = non-support.

Macroinvertebrate communities

Benthic assemblages at the eight sites on the Teton River and its North Fork can be grouped into two quite distinct community types based on taxa shared between sites. The assemblages generally separated along ecoregion lines, with many taxa shared among the Plains ecoregions sites, and others shared among the MVFP sites. Among the Plains ecoregions sites, however, the assemblage at Dent's bridge was somewhat distinctive, sharing nine taxa with the site at Loma, but fewer with the other Plains sites. The benthic community at Breen's was transitional, sharing several taxa with Plains sites. Figure 15 illustrates similarities and differences among the sites by compiling the number of taxa shared between benthic assemblages.

Figure 15. Similarity of benthic communities, expressed as the number of taxa in common between two communities. Teton River and North Fork Teton River. July and August 1998.

	At Loma	**Dent bridge**	**Kerr bridge**	**At I-15**	**Hwy.221**	**At Breen's**	**Gauging station**
Dent bridge	9						
Kerr bridge	12	5					
At I-15	12	7	16				
Hwy.221	8	4	10	12			
At Breen's	5	2	5	6	8		
Gauging station	1	1	0	1	2	8	
North Fork	1	1	0	2	0	11	14

1. The Montana Plains ecoregions sites.

In general, both the MT DEQ reference and the internal reference assigned bioassessment scores and impairment classifications consistently to Plains ecoregions sites on the Teton River. The benthic assemblage sampled at Loma had the lowest biotic index score of any of the five Plains ecoregions sites, suggesting that water quality at this lowermost site did not limit biotic health. The dominant taxon at this site, the leptophlebiid mayfly *Traverella albertana*, prefers the sandy substrate reported here, and the nature of the substrate was further elucidated by the presence of *Ephoron album*. This mayfly constructs tubular burrows and its presence here and at two other Plains sites in this study suggests that the substrate where burrows are located was stable and not highly prone to scour. Other sand tolerant organisms collected here include the baetid mayfly *Camelobaetidius* sp. and the midge *Robackia* sp. Fine sediment apparently did not limit biotic integrity here, since five caddisfly taxa were present. Loss of caddisfly taxa has been linked to sediment deposition (Bollman 1998), and although that finding was specific to the Montana Valleys and Foothill Prairies ecoregion, it appears in this case to be relevant, since many of the taxa found in these Plains sites are also characteristic of the MVFP as well. In addition, insect clingers were a significant component of the community. These included the hydropsychid caddisflies *Hydropsyche* sp. and *Cheumatopsyche* sp., and the glossomatid *Protoptila* sp., the dipteran *Simulium* sp., and the stonefly *Acroneuria* sp. Clingers are susceptible to displacement by sediment deposition.

As previously noted, the assemblage sampled at Dent bridge shared a moderate number of taxa with the site at Loma, but had fewer taxa in common with the other Plains ecoregions sites. In addition, the site produced the lowest taxa richness of any in the study. Both of these observations may be attributed to the very small sample size representing the site; the density of macroinvertebrates, expressed as the number of organisms collected per minute of substrate disturbance, was lowest here. However, other evidence supports the interpretation that the low density of benthic organisms was a symptom of habitat degradation, which impaired biotic health at the site. Scraping organisms are absent from the sample, suggesting that sediment deposition may be limiting habitat for these organisms. In addition, the number of clinging insects was very low; only a single stonefly was collected, and very few *Simulium* sp. or *Cheumatopsyche* sp. were present. While *Traverella*, which made up 39% of the sampled assemblage, is considered a clinger, this insect is not as dependent on surfaces as are other clingers, often preferring the undersides of rocks to their upper surfaces. Warm water temperatures, measured at 28°C, coupled with diminished flows at this site, were reflected in the high proportion of tubificid worms (13% of the assemblage), and the low EPT richness (5 taxa) and low EPT percent (58%). The biotic index (4.35) was appropriate for the Plains ecoregions, suggesting that organic and/or nutrient enrichment may not explain these observations at this site, but such an influence cannot be ruled out, since small sample sizes tend to favor low biotic index scores. The site at Dent bridge received the lowest bioassessment score of any site regardless of which set of reference criteria was used.

Macroinvertebrate density was also low at the Kerr bridge site; however, in contrast to the assemblage at Dent bridge, taxa richness was more than 90% greater at Kerr bridge. Thirteen EPT taxa were collected at Kerr bridge, and mayflies, stoneflies and caddisflies made up 85% of the sampled assemblage. These observations, together with the presence of the long-lived perlid stonefly *Acroneuria abnormis* suggests that severely diminished flows did not limit biotic integrity at this site. Many taxa of clinging insects were collected here, including the caddisflies *Brachycentrus occidentalis*, *Protoptila* sp., *Hydropsyche* sp. and the mayfly *Leucrocuta* sp.; six caddisfly taxa were present here. These observations suggest that fine sediment deposition did not impair the benthic community here.

Regardless of the reference criteria used, the bioassessment score at the Interstate 15 site was the highest of any of the Plains sites. Macroinvertebrate density was moderately low at this site, though not as low as at either Dent bridge or Kerr bridge. Still, this site produced the highest taxa richness (26) and EPT richness (18) of any Plains site. Stable sandy substrate was indicated by the abundance of *Ephoron album* (9% of the sample) collected here. The dominant taxon was the sediment-tolerant mayfly *Tricorythodes minutus*. However, scrapers comprised 24% of the assemblage, a greater proportion than at any other Plains site, strongly suggesting that sedimentation by fines was not severe enough to impair biotic health. Clingers, too, were abundant, including the heptageniid mayflies *Epeorus longimanus* and *Leucrocuta* sp., as well as several other insect taxa. In addition, six caddisfly taxa were collected here. The presence of eleven mayfly taxa imply that water quality was not a limitation to biotic health, although the conductance measurement was moderately high (0.90 mmhos/cm).

The highest conductance measurement at any Plains site (1.3 mmhos/cm) was recorded at the Highway 221 bridge. Still, six mayfly taxa were collected here, including strong representation by the moderately sensitive siphlonurid *Isonychia* sp. (5% of the sampled assemblage). The biotic index here (4.43) was within the range expected of Plains streams with water quality unimpaired by organic and/or nutrient pollution. As at the other Plains sites on the Teton River, there was no specific indication of water quality impairment in the benthic macroinvertebrate data collected at the Highway 221 bridge. Clinging insects were well-represented in the sample, with the caddisfly *Hydropsyche* sp. among the dominant organisms present (28%). This suggests that fine sediment did not limit biotic integrity here.

2. The Montana Valleys and Foothill Prairies ecoregion sites

Bioassessment scores for two of the MVFP sites varied considerably with the reference method used. All three methods, however, scored the North Fork site consistently.

The benthic assemblage collected at Breen's appears to represent a transition between the communities of the Plains sites and those of the MVFP sites upstream. It shared an average of five taxa with each of the Plains sites, while the other two MVFP sites averaged one taxon in common with any Plains site. Total bioassessment score varied here from 54% of reference to 83% and the impairment classification of the site varied from slight impairment to non-impairment depending on which reference criteria were used. The site had the highest taxa richness (41) of any site studied, with thirteen chironomid taxa; this pattern of taxonomic composition suggests the effect of a mild-to-moderate influence of organic and/or nutrient pollution. A biotic index score (4.48), somewhat elevated for a site in the MVFP ecoregion, was calculated for this assemblage. Further evidence for water quality degradation includes a high percentage of multivoltine taxa, which comprise 47% of the sampled community. The dominant taxon was the tolerant midge *Polypedilum* sp.; midges made up more than 50% of the organisms in the sample. Even though the seven Trichoptera taxa collected here seem to indicate that sediment deposition did not impair biotic integrity, the fact that caddisflies made up only 4% of the sample is evidence to the contrary.

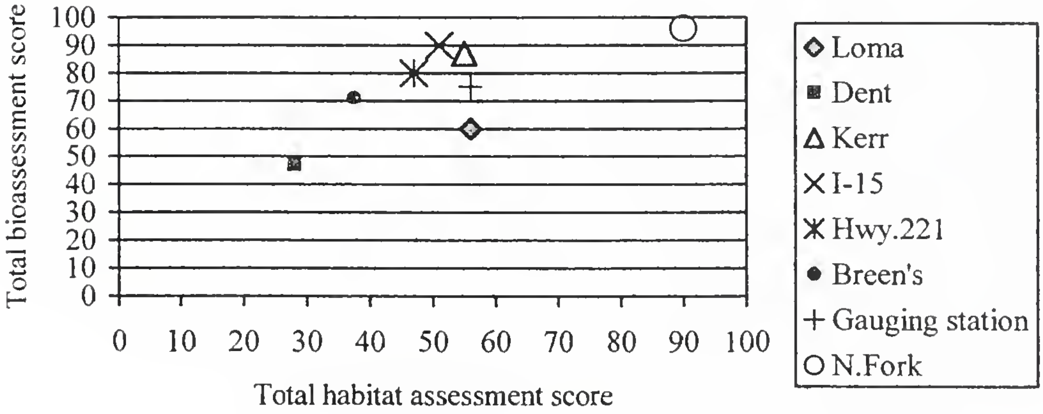
Where the revised bioassessment method seems to have overestimated biotic health at Breen's, it seems to have been more accurate than the other two methods at assessing conditions at the gauging station. Macroinvertebrate density at this site was very low. Perhaps because of the small sample size, the taxa richness and EPT richness metrics were reduced. Poor instream flow retention could account for the paucity of benthic organisms here. Most affected were caddisflies and stoneflies; there were only three taxa from the two orders in the sample. Seven mayfly taxa were present, and the biotic index was calculated to be 1.55. These observations suggest that water quality does not impair the community integrity at the gauging station.

The benthic assemblage collected at the North Fork site typified a non-impaired MVFP community. Five highly sensitive taxa were present, including the blephariceriid fly *Bibiocephala* sp., the mayfly *Drunella doddsi*, and the predatory net-spinner *Parapsyche elsis*. Nine mayfly taxa were collected, suggesting that water quality is not impaired, as does the low biotic index (1.46) calculated for the community here.

CONCLUSIONS

- Figure 9 illustrates the relationship between total habitat score and total bioassessment score (using ecoregion references) for all eight sites. Most sites show the typical relationship between the two scores when water quality is essentially unimpaired. The position of the symbol for the site at Loma, however suggests some impairment of water quality; the bioassessment score is lower than the habitat assessment score seems to predict.

Figure 9. Bioassessment score vs. habitat score. Teton River. July and August 1998.



- Teton River sites in the Plains ecoregions generally had communities adapted to sandy substrates with little scour, and four of the five sites had little evidence of impairment by fine sediment deposition or water quality impairment. The exception was the site at Dent bridge, where macroinvertebrate density appeared to be very low. Functional and taxonomic composition of the assemblage at this site suggests impairment to biotic health due to sediment deposition and diminished flow.
- For the MVFP ecoregion site at Breen's, the revised bioassessment seems to overestimate the biotic health of the community. Macroinvertebrate data from this site was not easily interpreted, perhaps because the assemblage seemed to be transitional between a Plains ecoregions community and a Foothill prairie community. Mild-to-

moderate organic and/or nutrient pollution probably slightly impairs the biotic integrity here. Sediment deposition may also contribute to impairment.

- At the gauging station, flow limitations have apparently severely reduced macroinvertebrate densities, but the data suggests that water quality was not impaired.

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APPENDIX

Macroinvertebrate Taxonomic Data

Teton 8B At Loma 8.4.98

Taxon	#	%	BI^2	FFG^1
Oligochaeta: Tubificidae	5	1.70	10	CG
TOTAL: MISC. TAXA	5	1.70		
Ophiogomphus	7	2.38	5	PR
TOTAL: ODONATA	7	2.38		
Camelobaetidius (=Dactylobaetis)	1	0.34	4	CG
Ephoron album	5	1.70	4	CG
Leucrocuta	2	0.68	4	SC
Traverella	238	80.95	3	CG
Tricorythodes minutus	2	0.68	4	CG
TOTAL: EPHEMEROPTERA	248	84.35		
Acroneuria abnormis	1	0.34	2	PR
Isogenoides	1	0.34	3	PR
TOTAL: PLECOPTERA	2	0.68		
Protoptila	1	0.34	1	SC
Cheumatopsyche	18	6.12	5	CF
Hydropsyche	3	1.02	5	CF
Nectopsyche	1	0.34	2	SH
Oecetis	1	0.34	8	PR
TOTAL: TRICHOPTERA	24	8.16		
Ceratopogonidae	1	0.34	6	PR
Simulium	3	1.02	5	CF
TOTAL: DIPTERA	4	1.36		
Polypedilum	1	0.34	6	CG
Robackia	1	0.34	4	CG
Thienemannimyia	1	0.34	5	PR
Tvetenia Bavarica Gr.	1	0.34	5	CG
TOTAL: CHIRONOMIDAE	4	1.36		
GRAND TOTAL	294	100.00		

Aquatic Macroinvertebrate Data: Teton 8B: At Loma	8.4.98
Percent of sample used	78
Subsample size	294
Percent EPT	93
Taxa richness	20
EPT richness	12
Biotic Index	3.40
Percent dominant taxon	80.95
Percent dominance of five dominant taxa	92.85
Percent dominance of ten dominant taxa	96.59
Percent collectors (gatherers plus filterers)	94.55
Percent scrapers plus shredders	1.36
Percent Hydropsychinae of Trichoptera	88
Metals tolerance index	1.59
Shannon H (log2)	1.36
Evenness	.31
Brillouin H	.86
Simpson D	.66
EPT/Chironomidae	68.50
CTQa	77.80
Percent Baetidae of Ephemeroptera	0.4
%Ephemeroptera	84.35
%Plecoptera	.68
%Trichoptera	8.16
%Coleoptera	.00
%Diptera	1.36
%Chironomidae	1.36
Multivoltine	3.06
Univoltine	92.52
Semivoltine	4.42

Functional Feeding Groups	# taxa	% abundance
Predator	6	4.08
Collector-gatherer	8	86.39
Collector-filterer	3	8.16
Scraper	2	1.02
Shredder	1	.34

Estimated total number of organisms	377
Estimated number collected per foot	8
Estimated number collected per minute	377

Macroinvertebrate Taxonomic Data

Teton 10B Dent bridge 8.4.98

Taxon	#	%	BI[2]	FFG[1]
Oligochaeta: Tubificidae	4	12.90	10	CG
TOTAL: MISC. TAXA	4	12.90		
Ophiogomphus	1	3.23	5	PR
TOTAL: ODONATA	1	3.23		
Camelobaetidius (=Dactylobaetis)	2	6.45	4	CG
Traverella	12	38.71	3	CG
Choroterpes	1	3.23	2	CG
TOTAL: EPHEMEROPTERA	15	48.39		
Isogenoides	1	3.23	3	PR
TOTAL: PLECOPTERA	1	3.23		
Cheumatopsyche	2	6.45	5	CF
TOTAL: TRICHOPTERA	2	6.45		
Simulium	4	12.90	5	CF
TOTAL: DIPTERA	4	12.90		
Cladotanytarsus	1	3.23	7	CG
Polypedilum	2	6.45	6	CG
Robackia	1	3.23	4	CG
TOTAL: CHIRONOMIDAE	4	12.90		
GRAND TOTAL	31	100.00		

Aquatic Macroinvertebrate Data: Teton 10B: At Dent bridge	8.4.98
Percent of sample used	100
Subsample size	31
Percent EPT	58
Taxa richness	11
EPT richness	5
Biotic Index	4.74
Percent dominant taxon	38.71
Percent dominance of five dominant taxa	77.41
Percent dominance of ten dominant taxa	96.78
Percent collectors (gatherers plus filterers)	93.55
Percent scrapers plus shredders	0
Percent Hydropsychinae of Trichoptera	.00
Metals tolerance index	3.03
Shannon H (log2)	2.86
Evenness	.83
Brillouin H	1.60
Simpson D	.17
EPT/Chironomidae	4.50
CTQa	82.91
Percent Baetidae of Ephemeroptera	13
%Ephemeroptera	48.39
%Plecoptera	3.23
%Trichoptera	6.45
%Coleoptera	.00
%Diptera	12.90
%Chironomidae	12.91
Multivoltine	16.13
Univoltine	74.19
Semivoltine	9.68

Functional Feeding Groups	# taxa	% abundance
Predator	2	6.46
Collector-gatherer	7	74.20
Collector-filterer	2	19.35
Scraper	0	.00
Shredder	0	.00

Estimated total number of organisms	31
Estimated number collected per foot	unknown
Estimated number collected per minute	31

Macroinvertebrate Taxonomic Data

Teton 11B Kerr bridge 8.4.98

Taxon	#	%	BI[2]	FFG[1]
Oligochaeta: Lumbriculidae	2	1.71	10	CG
Sphaeriidae	1	0.85	8	CF
TOTAL: MISC. TAXA	3	2.56		
Ophiogomphus	8	6.84	5	PR
TOTAL: ODONATA	8	6.84		
Acentrella insignificans	2	1.71	4	CG
Brachycercus	1	0.85	7	CG
Ephoron album	12	10.26	4	CG
Leucrocuta	19	16.24	4	SC
Traverella	26	22.22	3	CG
Tricorythodes minutus	3	2.56	4	CG
TOTAL: EPHEMEROPTERA	63	53.85		
Acroneuria abnormis	7	5.98	2	PR
TOTAL: PLECOPTERA	7	5.98		
Brachycentrus occidentalis	1	0.85	2	CF
Protoptila	1	0.85	1	SC
Cheumatopsyche	13	11.11	5	CF
Hydropsyche	11	9.40	5	CF
Ithytrichia	1	0.85	3.5	SC
Oecetis	2	1.71	8	PR
TOTAL: TRICHOPTERA	29	24.79		
Ordobrevia nubifera	1	0.85	5	CG
TOTAL: COLEOPTERA	1	0.85		
Ceratopogonidae	1	0.85	6	PR
Hemerodromia	1	0.85	6	PR
TOTAL: DIPTERA	2	1.71		
Cladotanytarsus	1	0.85	7	CG
Polypedilum	3	2.56	6	CG
TOTAL: CHIRONOMIDAE	4	3.42		
GRAND TOTAL	117	100.00		

Aquatic Macroinvertebrate Data: Teton 11B: Kerr bridge	8.4.98
Percent of sample used	100
Subsample size	117
Percent EPT	85
Taxa richness	21
EPT richness	13
Biotic Index	4.24
Percent dominant taxon	22.22
Percent dominance of five dominant taxa	69.23
Percent dominance of ten dominant taxa	88.88
Percent collectors (gatherers plus filterers)	65.78
Percent scrapers plus shredders	19.94
Percent Hydropsychinae of Trichoptera	83
Metals tolerance index	3.10
Shannon H (log2)	3.52
Evenness	.80
Brillouin H	2.21
Simpson D	.11
EPT/Chironomidae	24.75
CTQa	79.29
Percent Baetidae of Ephemeroptera	3
%Ephemeroptera	53.84
%Plecoptera	5.98
%Trichoptera	24.77
%Coleoptera	.85
%Diptera	1.70
%Chironomidae	3.41
Multivoltine	9.62
Univoltine	69.44
Semivoltine	20.94

Functional Feeding Groups	# taxa	% abundance
Predator	5	16.23
Collector-gatherer	9	43.57
Collector-filterer	4	22.21
Scraper	3	17.94
Shredder	0	.00

Estimated total number of organisms	117
Estimated number collected per foot	5
Estimated number collected per minute	117

Macroinvertebrate Taxonomic Data

Teton 12B At 1-15 8.5.98

Taxon	#	%	BI^2	FFG^1
Oligochaeta: Tubificidae: Limnodrilus	9	5.33	10	CG
Ferrissia	1	0.59	6	SC
TOTAL: MISC. TAXA	10	5.92		
Ophiogomphus	1	0.59	5	PR
TOTAL: ODONATA	1	0.59		
Camelobaetidius (=Dactylobaetis)	2	1.18	4	CG
Acentrella insignificans	3	1.78	4	CG
Procloeon	1	0.59	5	CG
Brachycercus	1	0.59	7	CG
Ephoron album	15	8.88	4	CG
Epeorus longimanus	1	0.59	1	SC
Leucrocuta	37	21.89	4	SC
Traverella	3	1.78	3	CG
Choroterpes	2	1.18	2	CG
Isonychia	1	0.59	2.5	CF
Tricorythodes minutus	44	26.04	4	CG
TOTAL: EPHEMEROPTERA	110	65.09		
Acroneuria abnormis	1	0.59	2	PR
TOTAL: PLECOPTERA	1	0.59		
Brachycentrus occidentalis	1	0.59	2	CF
Protoptila	1	0.59	1	SC
Cheumatopsyche	10	5.92	5	CF
Hydropsyche	22	13.02	5	CF
Mayatrichia	1	0.59	1	SC
Oecetis	2	1.18	8	PR
TOTAL: TRICHOPTERA	37	21.89		
Ceratopogonidae	1	0.59	6	PR
Dicranota	1	0.59	3	PR
TOTAL: DIPTERA	2	1.18		
Cladotanytarsus	3	1.78	7	CG
Orthocladius	1	0.59	6	CG
Polypedilum	4	2.37	6	CG
TOTAL: CHIRONOMIDAE	8	4.73		
GRAND TOTAL	169	100.00		

Aquatic Macroinvertebrate Data: Teton 12B: At I-15	8.5.98
Percent of sample used	100
Subsample size	169
Percent EPT	88
Taxa richness	26
EPT richness	18
Biotic Index	4.59
Percent dominant taxon	26.04
Percent dominance of five dominant taxa	75.75
Percent dominance of ten dominant taxa	88.79
Percent collectors (gatherers plus filterers)	72.21
Percent scrapers plus shredders	24.25
Percent Hydropsychinae of Trichoptera	86
Metals tolerance index	4.15
Shannon H (log2)	3.38
Evenness	.72
Brillouin H	2.14
Simpson D	.14
EPT/Chironomidae	18.50
CTQa	71.04
Percent Baetidae of Ephemeroptera	5
%Ephemeroptera	65.09
%Plecoptera	.59
%Trichoptera	21.89
%Coleoptera	.00
%Diptera	1.18
%Chironomidae	4.74
Multivoltine	11.39
Univoltine	79.73
Semivoltine	8.88

Functional Feeding Groups	# taxa	% abundance
Predator	5	3.54
Collector-gatherer	12	52.09
Collector-filterer	4	20.12
Scraper	5	24.25
Shredder	0	.00

Estimated total number of organisms	169
Estimated number collected per foot	5
Estimated number collected per minute	169

Macroinvertebrate Taxonomic Data

Teton 14B Highway 221 bridge 8.5.98

Taxon	#	%	BI[2]	FFG[1]
Nematoda: Mermithidae	12	3.82	5	OM
Oligochaeta: Lumbriculidae	2	0.64	10	CG
Physella	6	1.91	8	SC
Gammarus	1	0.32	4	CG
TOTAL: MISC. TAXA	21	6.69		
Acentrella insignificans	2	0.64	4	CG
Baetis tricaudatus	13	4.14	4	CG
Leucrocuta	16	5.10	4	SC
Choroterpes	11	3.50	2	CG
Isonychia	16	5.10	2.5	CF
Tricorythodes minutus	91	28.98	4	CG
TOTAL: EPHEMEROPTERA	149	47.45		
Skwala	1	0.32	3	PR
TOTAL: PLECOPTERA	1	0.32		
Brachycentrus occidentalis	12	3.82	2	CF
Cheumatopsyche	3	0.96	5	CF
Hydropsyche	87	27.71	5	CF
Mayatrichia	2	0.64	1	SC
Oecetis	8	2.55	8	PR
TOTAL: TRICHOPTERA	112	35.67		
Dubiraphia	2	0.64	6	SC
Optioservus	18	5.73	5	SC
TOTAL: COLEOPTERA	20	6.37		
Cladotanytarsus	1	0.32	7	CG
Microtendipes	1	0.32	6	CG
Polypedilum	6	1.91	6	CG
Rheotanytarsus	1	0.32	6	CF
Thienemannimyia	1	0.32	5	PR
Tvetenia Bavarica Gr.	1	0.32	5	CG
TOTAL: CHIRONOMIDAE	11	3.50		
GRAND TOTAL	314	100.00		

Aquatic Macroinvertebrate Data: Teton 14B: At Highway 221	8.5.98
Percent of sample used	60
Subsample size	314
Percent EPT	83
Taxa richness	24
EPT richness	12
Biotic Index	4.43
Percent dominant taxon	28.98
Percent dominance of five dominant taxa	72.62
Percent dominance of ten dominant taxa	90.45
Percent collectors (gatherers plus filterers)	79.00
Percent scrapers plus shredders	14.02
Percent Hydropsychinae of Trichoptera	80
Metals tolerance index	4.23
Shannon H (log2)	3.21
Evenness	.70
Brillouin H	2.11
Simpson D	.17
EPT/Chironomidae	23.82
CTQa	87.17
Percent Baetidae of Ephemeroptera	10
%Ephemeroptera	47.46
%Plecoptera	.32
%Trichoptera	35.68
%Coleoptera	6.37
%Diptera	.00
%Chironomidae	3.51
Multivoltine	17.68
Univoltine	71.82
Semivoltine	10.51

Functional Feeding Groups	# taxa	% abundance
Predator	3	3.19
Collector-gatherer	10	41.09
Collector-filterer	5	37.91
Scraper	5	14.02
Shredder	0	.00

Estimated total number of organisms	523
Estimated number collected per foot	17
Estimated number collected per minute	523

Macroinvertebrate Taxonomic Data

Teton 2 At Breen's 7.23.98

Taxon	#	%	BI[2]	FFG[1]
Oligochaeta: Naididae	4	1.32	10	CG
Ostracoda	4	1.32	8	CG
Acari	3	0.99	5	PA
TOTAL: MISC. TAXA	11	3.64		
Acentrella insignificans	5	1.66	4	CG
Baetis tricaudatus	16	5.30	4	CG
Diphetor hageni	6	1.99	5	CG
Attenella margarita	8	2.65	2	SC
Serratella tibialis	1	0.33	2	CG
Heptageniidae	2	0.66	4	SC
TOTAL: EPHEMEROPTERA	38	12.58		
Chloroperlidae	9	2.98	1	PR
Amphinemura	2	0.66	2	SH
Calineuria californica	41	13.58	2	PR
Hesperoperla pacifica	1	0.33	1	PR
Pteronarcella	2	0.66	4	SH
TOTAL: PLECOPTERA	55	18.21		
Brachycentrus americanus	3	0.99	1	SC
Brachycentrus occidentalis	3	0.99	2	CF
Hydropsyche	2	0.66	5	CF
Hydroptila	1	0.33	6	CG
Onocosmoecus	1	0.33	3	OM
Wormaldia	2	0.66	0	CF
Rhyacophila (imm.)	1	0.33	1	PR
TOTAL: TRICHOPTERA	13	4.30		
Dytiscidae	7	2.32	5	PR
Optioservus	6	1.99	5	SC
Zaitzevia	7	2.32	4	CG
TOTAL: COLEOPTERA	20	6.62		
Ceratopogonidae	1	0.33	6	PR
Chelifera	1	0.33	5	PR
Simulium	4	1.32	5	CF
Hexatoma	7	2.32	2	PR
TOTAL: DIPTERA	13	4.30		
Corynoneura	4	1.32	7	CG
Eukiefferiella Claripennis Gr.	4	1.32	8	CG
Eukiefferiella Pseudomontana Gr.	21	6.95	8	CG
Micropsectra	34	11.26	4	CG
Orthocladius	7	2.32	6	CG
Pagastia	2	0.66	1	CG
Parametriocnemus	1	0.33	5	CG
Polypedilum	51	16.89	6	CG
Rheocricotopus	5	1.66	4	CG
Stempellinella	1	0.33	4	UN
Thienemanniella	3	0.99	6	CG
Thienemannimyia	6	1.99	5	PR
Tvetenia Bavarica Gr.	13	4.30	5	CG
TOTAL: CHIRONOMIDAE	152	50.33		
GRAND TOTAL	302	100.00		

Aquatic Macroinvertebrate Data: Teton 2 : At Breen's	7.23.98
Percent of sample used	100
Subsample size	302
Percent EPT	35
Taxa richness	41
EPT richness	18
Biotic Index	4.48
Percent dominant taxon	16.89
Percent dominance of five dominant taxa	53.98
Percent dominance of ten dominant taxa	68.55
Percent collectors (gatherers plus filterers)	66.20
Percent scrapers plus shredders	7.61
Percent Hydropsychinae of Trichoptera	15
Metals tolerance index	3.81
Shannon H (log2)	4.40
Evenness	.82
Brillouin H	2.84
Simpson D	.07
EPT/Chironomidae	.70
CTQa	75.88
Percent Baetidae of Ephemeroptera	71
%Ephemeroptera	12.59
%Plecoptera	18.21
%Trichoptera	4.29
%Coleoptera	6.63
%Diptera	4.30
%Chironomidae	50.32
Multivoltine	47.19
Univoltine	28.81
Semivoltine	24.01

Functional Feeding Groups	# taxa	% abundance
Predator	9	24.51
Collector-gatherer	19	62.57
Collector-filterer	4	3.63
Scraper	4	6.29
Shredder	2	1.32

Estimated total number of organisms	302
Estimated number collected per foot	9
Estimated number collected per minute	302

Macroinvertebrate Taxonomic Data

Teton 1 Gauging station 7.20.97

Taxon	#	%	BI[2]	FFG[1]
Baetis tricaudatus	6	5.45	4	CG
Drunella coloradensis	5	4.55	0	CG
Drunella doddsi	2	1.82	1	SC
Serratella tibialis	5	4.55	2	CG
Cinygmula	43	39.09	0	SC
Epeorus longimanus	20	18.18	1	SC
Rhithrogena	2	1.82	0	SC
TOTAL: EPHEMEROPTERA	83	75.45		
Hesperoperla pacifica	1	0.91	1	PR
TOTAL: PLECOPTERA	1	0.91		
Brachycentrus americanus	1	0.91	1	SC
Glossosoma	1	0.91	0	SC
TOTAL: TRICHOPTERA	2	1.82		
Simulium	17	15.45	5	CF
Hexatoma	1	0.91	2	PR
TOTAL: DIPTERA	18	16.36		
Eukiefferiella Gracei Gr.	2	1.82	4	CG
Micropsectra	2	1.82	4	CG
Rheocricotopus	1	0.91	4	CG
Tvetenia Bavarica Gr.	1	0.91	5	CG
TOTAL: CHIRONOMIDAE	6	5.45		
GRAND TOTAL	110	100.00		

Aquatic Macroinvertebrate Data: Teton 1 : Gauging station	7.20.97
Percent of sample used	100
Subsample size	110
Percent EPT	78
Taxa richness	16
EPT richness	10
Biotic Index	1.55
Percent dominant taxon	39.09
Percent dominance of five dominant taxa	82.72
Percent dominance of ten dominant taxa	94.55
Percent collectors (gatherers plus filterers)	35.46
Percent scrapers plus shredders	62.73
Percent Hydropsychinae of Trichoptera	00
Metals tolerance index	1.49
Shannon H (log2)	2.82
Evenness	.70
Brillouin H	1.76
Simpson D	.21
EPT/Chironomidae	14.33
CTQa	51.44
Percent Baetidae of Ephemeroptera	6
%Ephemeroptera	75.46
%Plecoptera	.91
%Trichoptera	1.82
%Coleoptera	.00
%Diptera	16.36
%Chironomidae	5.46
Multivoltine	8.18
Univoltine	90.00
Semivoltine	1.82

Functional Feeding Groups	# taxa	% abundance
Predator	2	1.82
Collector-gatherer	7	20.01
Collector-filterer	1	15.45
Scraper	6	62.73
Shredder	0	.00

Estimated total number of organisms	110
Estimated number collected per foot	4
Estimated number collected per minute	110

Macroinvertebrate Taxonomic Data

NF Teton 2 North Fork 7.22.98

Taxon	#	%	BI[2]	FFG[1]
Gyraulus	1	0.30	8	SC
TOTAL: MISC. TAXA	1	0.30		
Ameletus	1	0.30	0	SC
Baetis tricaudatus	10	3.00	5	CG
Drunella coloradensis	8	2.42	0	CG
Drunella doddsi	29	8.76	1	SC
Drunella spinifera	1	0.30	0	PR
Serratella tibialis	38	11.48	2	CG
Cinygmula	84	28.10	0	SC
Epeorus longimanus	61	18.43	1	SC
Rhithrogena	8	2.42	0	SC
TOTAL: EPHEMEROPTERA	238	71.90		
Chloroperlidae	1	0.30	1	PR
Zapada cinctipes	1	0.30	3	SH
Hesperoperla pacifica	1	0.30	1	PR
Isoperla	1	0.30		PR
TOTAL: PLECOPTERA	4	1.21		
Parapsyche elsis	2	0.60	0	CF
Brachycentrus americanus	2	0.60	1	SC
Glossosoma	9	2.72	0	SC
Rhyacophila Brunnea Gr.	4	1.21	2	PR
Rhyacophila Coloradensis Gr.	1	0.30	0	PR
TOTAL: TRICHOPTERA	18	5.44		
Bibiocephala	2	0.60	0	SC
Simulium	25	9.06	5	CF
Antocha	1	0.30	3	CG
Hexatoma	1	0.30	2	PR
TOTAL: DIPTERA	34	10.27		
Eukiefferiella Gracei Gr.	14	4.23	4	CG
Micropsectra	16	4.83	4	CG
Orthocladius	1	0.30	6	CG
Pagastia	3	0.91	1	CG
Rheocricotopus	1	0.30	4	CG
Thienemanniella	1	0.30	6	CG
TOTAL: CHIRONOMIDAE	36	10.88		
GRAND TOTAL	328	100.00		

Aquatic Macroinvertebrate Data: NF Teton 2 : North Fork	7.22.98
Percent of sample used	55
Subsample size	330
Percent EPT	79
Taxa richness	29
EPT richness	18
Biotic Index	1.46
Percent dominant taxon	28.10
Percent dominance of five dominant taxa	75.83
Percent dominance of ten dominant taxa	92.45
Percent collectors (gatherers plus filterers)	34.73
Percent scrapers plus shredders	62.23
Percent Hydropsychinae of Trichoptera	00
Metals tolerance index	1.33
Shannon H (log2)	3.32
Evenness	.70
Brillouin H	2.18
Simpson D	.15
EPT/Chironomidae	7.22
CTQa	45.59
Percent Baetidae of Ephemeroptera	0
%Ephemeroptera	71.91
%Plecoptera	1.20
%Trichoptera	5.43
%Coleoptera	.00
%Diptera	10.26
%Chironomidae	10.87
Multivoltine	8.16
Univoltine	89.58
Semivoltine	2.27

Functional Feeding Groups	# taxa	% abundance
Predator	7	3.01
Collector-gatherer	9	25.07
Collector-filterer	2	9.66
Scraper	8	61.93
Shredder	1	.30

Estimated total number of organisms	600
Estimated number collected per foot	17
Estimated number collected per minute	600

Hannaea

1032 Twelfth Avenue • Helena, MT 59601 • (406) 443-2196
e-mail: lbahls@selway.umt.edu

February 16, 1999

Ms. Carol Endicott
Monitoring and Data Management Bureau
Department of Environmental Quality
P.O. Box 200901
Helena, MT 59620-0901

Re: McDonald Creek and Teton River Periphyton Report

Dear Carol,

Enclosed is a copy of my report on periphyton samples collected last summer from McDonald Creek and the Teton River.

The Teton River at Dent Bridge was the only site that did not fully support aquatic life uses based on periphyton composition and community structure. The partial support recorded at this site was probably due to excessive sedimentation and homogeneity of algal microhabitats. The myriad of other insults to the Teton (dewatering, salinity, nutrients...) did not have a huge effect on periphyton composition and community structure.

Bob Bukantis called today to ask if I would give a seminar on interpreting periphyton data. I suggested using this report as the basis for discussion, so he may ask to copy this report for those who will attend the seminar.

Please let me know if you have any questions or if you want the results presented differently. The report is in my computer so I can easily correct errors or make changes.

Thanks for the work. My invoice is enclosed. By the way, your agency purchase order lists my telephone number as my federal ID number. If you need my Social Security Number, it's 474-48-9443.

Sincerely,

Loren Bahls

Loren L. Bahls, Ph.D.
Phycologist

Enclosures (Teton River Report and Invoice)

Frustulia bahlsii Edlund and Brant

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BIOASSESSMENT OF SEVEN SITES ON THE TONGUE RIVER

Big Horn, Rosebud, and Custer Counties, Montana

September 2001

report prepared for
The Montana Department of Environmental Quality
Helena, Montana

by
Wease Bollman
Rhithron Associates, Inc.
Missoula, Montana

December 2002

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INTRODUCTION

Benthic assemblages are aptly applied to aquatic bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

Multimetric approaches to bioassessment use attributes of the assemblage in an integrated way to measure biotic integrity, defined by Karr and Dudley as "...the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitats within a region." The additive multimetric approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of aquatic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1995). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998). The first element is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied must be done, to assist in the interpretation of metric outcomes.

Relevant habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by quantities of organic materials, nutrients, metals, or other toxicants might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment. Habitat assessment data is even more important in the plains ecoregions, where the relationships between habitat variables and benthic community characteristics remain largely unknown.

This report summarizes data collected in September 2001 on the Tongue River, using a multimetric method of analysis, an adaptation of the U.S. EPA's Rapid Bioassessment Protocols (RBP III) (Plafkin et al. 1989). Invertebrates were collected at seven sites on the Tongue River, which is tributary to the Yellowstone River located in the Northwestern Great Plains ecoregion (Woods et al. 1999).

Selection of bioassessment metrics and evaluation of benthic community attributes for this study were not straightforward tasks. The standard operating procedures manual for aquatic invertebrate sampling and analysis of the Montana Department of Environmental Quality (Montana DEQ) (Bukantis 1998) recommends the use of ten metrics for assessing biota of streams in the Montana plains ecoregions. Implicit in the multimetric method is an assumption of correlative relationships between disturbance, habitat measures, and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of independent measures of human-caused disturbance, habitat

assessment elements, and biotic metrics and a test of the presumed relationship between them. Assurance of the validity of association between disturbance, habitat measures, and biotic metrics is particularly compelling in the Montana plains ecoregions through which the Tongue River flows, since impairment of the biotic health of streams in this region is generally the result of non-point sources related to human-caused disturbances. Agricultural activities, cattle grazing, and flow alteration are predominant causes of stream degradation. The benthic assemblages of the plains ecoregions and the performance of the recommended bioassessment metrics have not yet been examined thoroughly enough to determine whether or not the individual metrics or their integrated scores can discriminate impaired conditions from good biotic health. This author (Bollman 1998) evaluated bioassessment metrics for the Montana valleys and foothill prairies ecoregion, and found that many metrics recommended for use in that region were not accurate in discriminating impaired from unimpaired conditions. However, analysis of benthic communities based on the taxonomic composition of the assemblages collected is probably a valid approach to bioassessment in the plains ecoregions. Thus, while bioassessment scores must be regarded cautiously, observations based on characteristics of taxa present in samples is likely to reveal reliable information about water quality and habitat condition. To maximize the reliability of assessments, Montana DEQ requires this type of information in addition to bioassessment indices and scores to assist in management decisions. Bioassessment scores presented in this report must be considered tentative, and the data should be reconsidered in the future, after research has been done to better elucidate these relationships. Conclusions and observations based upon characteristics of the taxa present in samples is likely to be the most reliable source of information concerning water quality and instream and riparian habitat conditions for purposes of resource management.

METHODS

Aquatic invertebrates were sampled from seven sites on the Tongue River on September 21-22, 2001. Sampling site locations, identifiers, and descriptions are given in Table 1.

No habitat assessment was available. Invertebrate samples were delivered to Rhithron Associates, Inc., Missoula, Montana, for laboratory and data analyses. In the laboratory, the RBP III sorting method was used to obtain subsamples of 300 (+/- 10%) organisms from each sample when possible. When samples contained fewer than 300 total organisms, all invertebrates present were used. Community structure, function, and sensitivity to impact were characterized for each subsample using a battery of ten attributes, or metrics, recommended by Bukantis (1998) for streams of the Montana plains ecoregions (Table 2). Metric results were compared to reference criteria provisionally established by Montana DEQ for streams of the Plains ecoregions. Actual metric values from each sample were compared to ecoregional reference values to obtain scores. Scores for all metrics were combined, and a total bioassessment score was expressed as a percentage of the maximum possible score. Total bioassessment scores were interpreted in terms of aquatic life or other uses according to guidelines established by Montana DEQ (Bukantis 1998) and elaborated in Table 3 in this report.

Table 1. Sampling site identifiers, descriptions and locations on the Tongue River: September 21-22, 2001.

Site Identifier	Location	GPS location
Site 1	Above Tongue River Reservoir	45° 01' 15" N 106° 48' 38"W
Site 2	Below Tongue River Reservoir dam	45° 08' 27" N 106° 46' 13"W
Site 3	Above bridge near Prairie Dog Coulee	45° 15' 57" N 106° 37' 28"W
Site 4	Above Brandenburg Bridge	45° 50' 14" N 106° 13' 20"W
Site 5	Near Moon Creek Road (Woods Road)	45° 55' 44" N 106° 07' 31"W
Site 6	At Garland	46° 03' 01" N 105° 55' 56" W
Site 7	Near mouth	46° 24' 24"N 105° 51' 58" W

Table 2. Provisional metrics and scoring criteria for the Montana plains ecoregions; the Montana plains ecoregions reference. (Bukantis, 1998).

	Score			
Metric	**3**	**2**	**1**	**0**
Taxa richness	>24	24 - 18	18 – 12	<12
EPT richness	>8	8 – 6	5 – 3	<3
Biotic Index	<5	5 – 6	6 – 7	>7
% Dominant taxon	<30	30 – 45	45 – 60	>60
% Collectors	<60	60 – 80	80 – 95	>95
% EPT	>50	50 – 30	30 – 10	<10
Shannon H (log2)	>3.0	3.0 – 2.4	2.4 – 1.8	<1.8
% Scrapers + shredders	>30	30 – 15	15 – 3	<3
# Predator taxa	>5	4 – 5	3 – 4	<3
% Multivoltine	<40	40 - 60	60 – 80	>80

Table 3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis, 1997).

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table 3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

RESULTS

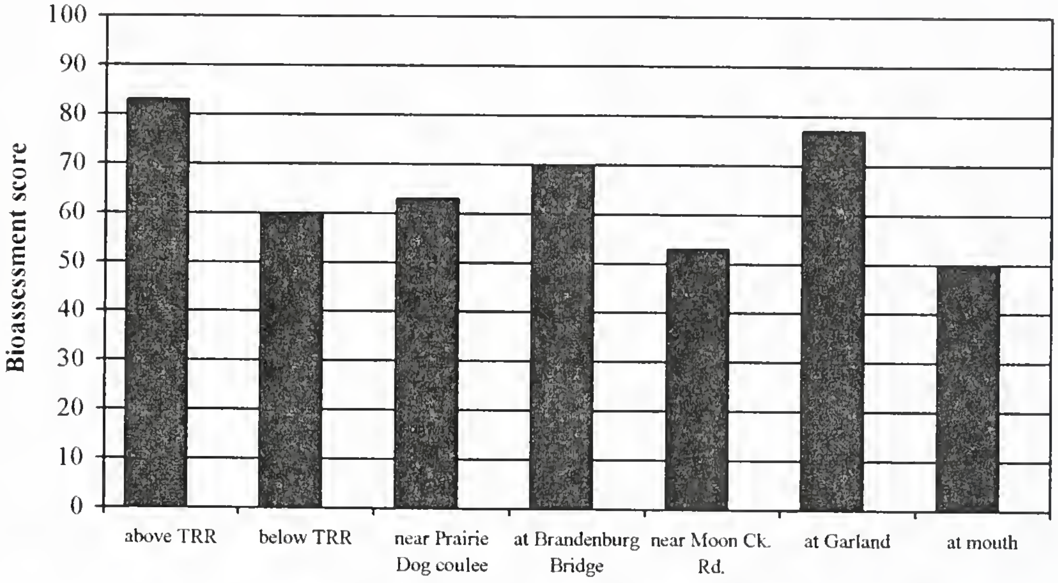
Bioasssessment

Aquatic invertebrate taxa lists, metric results and other information for each sample are given in the Appendix. Table 2 summarizes the metric battery used in the Montana DEQ Plains ecoregional reference method. Table 3a shows the Montana DEQ criteria for assignment of use-support categories, and Table 3b lists the criteria for the assignment of impairment classifications. Breakdown of scores for each metric calculated from the Tongue River aquatic invertebrate samples is presented in Table 4. Figure 1 compares the total bioassessment scores for all 7 sites when the aquatic invertebrate data was evaluated using the Montana DEQ plains ecoregions reference and metric battery, which are considered provisional. It is important to note that neither the metric battery used here nor any of its components has been tested for discriminatory power, accuracy, or precision in Plains ecoregions streams.

Bioassessment scores calculated by this method indicate partial support of designated uses and slight impairment of biotic health at 4 of the studied sites. Above the Tongue River Reservoir, scores indicate unimpaired biotic health and full support of designated uses. At Garland, very slight impairment was indicated by the bioassessment score, but the score fell within the range for full use support. At the mouth, scores indicated that biotic health was moderately impaired, and uses were partially supported. In general, total scores did not vary greatly over the length of the Tongue River; scores ranged from a low of 50% of maximum at the mouth of the Tongue River to a high of 83% of maximum at the site above the Tongue River Reservoir.

Biotic index scores were generally low (range 3.83 - 5.38) over the sampled length of the river, and EPT richness and EPT percent were both high at most sites; these findings suggest that water quality was generally good in the studied reaches of the Tongue River. Below the Tongue River Reservoir dam, near the Prairie Dog coulee, and at the mouth, EPT richness was lower than at the other locations. Most sites supported rich assemblages; the number of taxa collected at sites ranged from a low of 14 near the Moon Creek Road to a high of 28 above the Tongue River Reservoir.

Figure 1. Total bioassessment scores, expressed as percent of maximum score, for 7 sites on the Tongue River, September 21-22, 2001. Montana plains ecoregions reference used for comparison (Bukantis 1998).



Aquatic invertebrate communities

Above the Tongue River Reservoir, the biotic index value (5.38) calculated for the sampled assemblage was the highest among the sites visited for this study. However, 6 mayfly taxa were present in the sample taken here. These findings suggest that water quality was good, though temperatures may have been warm. Several animals that clearly prefer warmer water were collected at the site, including the caddisflies *Helicopsyche borealis* and *Cheumatopsyche* sp. Severe nutrient enrichment or inorganic pollutants do not appear to limit the benthic community at the site.

Benthic substrates appear to be comprised of both hard clean surfaces as well as areas of fine sediments. Ten "clinger" taxa were collected here, yet sediment-tolerant taxa, including the burrowing mayfly *Ephemera simulans* made up 42% of animals in the sample. The site supported the largest number of taxa among the sampled sites, suggesting that instream habitats were ample and diverse. All expected functional components of an integrated benthic community were present.

Below the reservoir, the benthic fauna was dominated by filter-feeders, especially the caddisflies *Cheumatopsyche* sp. and *Hydropsyche* sp. A functional shift toward filter-feeding is expected in dam-outflow habitats. The site supported a less rich assemblage than the site above the reservoir; only 16 taxa were collected. This suggests that habitats were more monotonous or limited at this site. Although only 6 "clinger" taxa were present in the sample, this group comprised nearly 60% of organisms in the sample, suggesting that clean hard substrates unimpaired by fine sediment deposition were available for colonization.

The number of mayfly taxa collected fell to 3, somewhat fewer than the upstream site, but the biotic index value (4.89) here was also lower. This suggests that water

Table 4. Aquatic bioassessment metrics and scores for 7 sites on the Tongue River, September 21-22, 2001. Montana plains ecoregions reference (Bukantis 1998).

VALUES	above TRR	below dam	near Prairie Dog Coulee	at Brandenburg bridge	near Moon Ck Road	at Garland	at mouth
Taxa richness	28	16	21	19	14	20	17
EPT richness	11	5	6	13	9	13	6
Biotic Index	5.38	4.89	5.08	4.54	4.54	3.83	4.48
% dominant taxon	31	30	63	46	64	39	32
% collectors	69	86	19	73	88	81	97
% EPT	55	73	15	85	92	83	37
Shannon diversity	3.09	2.34	2.23	2.47	2.12	2.47	2.74
% Shredders + scrapers	22	4	74	19	11	15	2
# Predator taxa	5	3	5	2	1	6	2
% Multivoltine	13	29	8	22	24	15	38
SCORES							
Taxa richness	3	1	2	2	1	2	1
EPT richness	3	1	2	3	3	3	2
Biotic Index	2	3	2	3	3	3	3
% dominant taxon	2	3	0	1	0	2	2
% collectors	2	1	3	2	1	1	0
% EPT	3	3	1	3	3	3	2
Shannon diversity	3	1	1	2	1	2	2
% Shredders + scrapers	2	1	3	2	1	1	0
# Predator taxa	2	1	2	0	0	3	0
% Multivoltine	3	3	3	3	3	3	3
TOTAL SCORE	25	18	19	21	16	23	15
PERCENT MAXIMUM	83	60	63	70	53	77	50
IMPAIRMENT CLASSIFICATION[1]	**NON**	**SLI**	**SLI**	**SLI**	**SLI**	**SLI**	**MOD**
USE SUPPORT[1]	**FULL**	**PART**	**PART**	**PART**	**PART**	**FULL**	**PART**

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[1] See Table 3a for impairment classification criteria and Table 3b for use support criteria.

quality continued to be good in this reach of the Tongue River, since the diminished mayfly richness appears to be more related to the generally lower taxa richness, and may be due to habitat limitations rather than to water quality degradation.

Near the Prairie Dog Coulee, the biotic index value (5.08) is slightly elevated. While 6 mayfly taxa were present in the sample, the proportion of mayflies in this assemblage (8.3%) is lower than at any of the Tongue River sites sampled. These findings are difficult to interpret, however, in light of the overwhelming abundance of the elmid beetle *Microcylloepus* sp. (63% of sampled organisms). The large numbers of this animal suggest that the sampler encountered a "bloom" of larvae, which may mask the actual taxonomic composition of the resident assemblage. *Microcylloepus* spp. that inhabit Eastern Montana, although classified by Wisseman (1996) as "clingers", are in fact tolerant of siltation and turbidity, and prefer warm water habitats. The "bloom" also may obscure the functional composition of the assemblage. With so many *Microcylloepus* sp., the sampled assemblage is strongly skewed toward scrapers; it is worth noting, however, that the functional role of this genus is not very well known.

At the Brandenburg Bridge, the biotic index value (4.54) together with the rich mayfly fauna (7 taxa) suggest water unimpaired by excessive nutrient enrichment or inorganic pollutants. Mayflies included the relatively intolerant heptageniid *Rhithrogena* sp., typically a reliable indicator of good water quality. The site supported 9 "clinger" taxa as well as 5 caddisfly taxa, suggesting that clean substrate habitats were plentiful and generally unaffected by fine sediment deposition. The Brandenburg Bridge site was one of two Tongue River sites that supported stoneflies: a single specimen of the perlodid *Isogenoides* sp. was collected here. While a single individual organism offers no conclusive evidence, the finding is certainly not a negative one; perlodid stoneflies require complex habitats. All expected functional components of a prairie stream community were present in the sample.

Only 189 organisms were collected in the sampling effort at this site. Whether the low abundance of organisms was due to depauperate communities at the site or to sampling bias is not clear from the data itself. However, information provided by the project manager (P. Newby, personal communication) suggests that large cobble substrates probably limited the abundance of organisms supported at the site. Midges were absent from the sample, which may suggest scouring flow conditions or large cobble substrates, both of which are potential limitations to the abundance of invertebrates.

Scouring flow may explain the absence of midges at the site near the Moon Creek Road as well. While overall abundance of animals was within expectations, taxa richness was low at this site. The sample was overwhelmed by filter-feeders, especially the hydropsychid caddisflies *Cheumatopsyche* sp., which comprised 64% of sampled organisms, and *Hydropsyche* sp., which added another 8%. The functional dominance of filter-feeders suggests that fine organic particles in suspension were plentiful at the site. Water quality appeared to be minimally affected by dissolved nutrients or inorganic pollution, since the biotic index value (4.54) was not elevated, and the site supported 6 mayfly taxa, including the prairie denizen *Camelobaetidius* sp. Eight "clinger" taxa were present in the sample, and while there were only 3 caddisfly taxa collected at the site, these taxa comprised 73% of the sampled organisms. The findings suggest minimal deposition of fine sediments, and plentiful hard clean substrate habitats.

The sample collected at Garland contained few organisms; only 147 were collected. Whether the low abundance of organisms was due to depauperate communities at the sites or to sampling bias is not clear from the data. However, information provided by field personnel (P. Newby, personal communication) suggests that large cobble substrates apparently limited abundance of animals at the site; small numbers of organisms were collected even though a vigorous sampling effort was applied. Still, the site supported the most sensitive assemblage among the studied reaches on the Tongue River. The biotic index calculated here was 3.83, and 7 mayfly taxa, including *Rhithrogena* sp., were collected; these findings imply good water quality. Fine sediment deposition appears to have had minimal effect on habitat quality, since 10 "clinger" taxa were present at the site; these included the perlid *Calineuria californica*, one of two stonefly taxa collected here. Complex and abundant instream habitats seem to have characterized the river in this reach. Functionally, filter-feeders dominated the site, suggesting abundant fine organic particles in suspension. All other expected functional components were present as well.

The moderate impairment of biotic integrity assessed by the metric battery at the mouth of the Tongue River seems to exaggerate conditions at the site. Good water quality is suggested by the low biotic index value (4.48) and by the fact that the site supported a considerable number of *Rhithrogena* sp. among the 4 mayfly taxa found there. Seven "clinger" taxa comprised nearly 50% of the sampled assemblage, implying that fine sediments did not obliterate hard substrate habitats. Sandy areas, indicated by the large numbers of the midge *Saetheria* sp., appear to add complexity to instream habitats here. Filter-feeders were prominent among the functional components of the community, as were gatherers; the abundance of these groups had a negative effect on bioassessment metric scores, but these findings are expected in downstream reaches of streams and rivers. Given the taxonomic and functional composition of the assemblage, impairment of biotic integrity seems slight.

CONCLUSIONS

- At most Tongue River sites, good water quality and intact instream habitats are suggested by the taxonomic and functional composition of benthic assemblages, in spite of relatively low bioassessment scores at some sites. High mayfly taxa richness and the presence of sensitive taxa such as *Rhithrogena* sp. at several sites strongly support the hypothesis of generally good water quality at these sites. The moderate impairment classification assigned to the site at the mouth of the river seems to exaggerate the disturbance there. However, information provided by the project manager (P. Newby, personal communication) suggests that dewatering and the resultant elevated water temperatures may be factors in the relatively low score there.

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APPENDIX

Taxonomic data and summaries

Tongue River

September 21-22, 2001